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NASA'S SPACE STATION ACTIVITIES

HEARING

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

AUGUST 2, 1983

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NASA'S SPACE STATION ACTIVITIES

TUESDAY, AUGUST 2, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:40 a.m., in room 2325, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Mr. VOLKMER. The subcommittee will come to order.

Today, the subcommittee will review the status, plans and activity associated with NASA's space station effort.

In 1969, NASA Administrator Tom Paine suggested that,

> The Nation should—focus our manned spaceflight program for the next decade on the development and operations of a permanent space station—a national research center in Earth orbit—accessible at reasonable costs to experts in many disciplines who can conduct investigations and operations in space which cannot be effectively carried out on Earth.

This position by Administrator Paine was the culmination of work done by NASA on a permanent manned station dating from at least mid-1959. As everyone well knows, the decision by the administration and Congress was to proceed with the space shuttle program versus space station for a variety of reasons.

Today, we are revisiting the space station concept and its potentials for a permanent manned presence in space. We look forward to hearing from NASA's space station task force leader, Mr. John Hodge, and also an emerging issue associated with our international friends as perceived by Mr. Ken Pedersen from NASA's Office of International Relations and their potential role in a space station endeavor.

Finally, we will hear from Mr. Peter Wright Hood—Wood, excuse me—senior vice president of Booz, Allen & Hamilton, Inc., who will tell us about the potential commercial users and their concerns at this stage of activity.

The subcommittee looks forward to the testimony so we may begin to focus on this issue which will be with us for several years to come.

[The prepared statement of Mr. Lujan follows:]

HONORABLE MANUEL LUJAN, JR.
HEARING ON NASA'S SPACE STATION
AUGUST 2, 1983

THANK YOU, MR. CHAIRMAN. I COMMEND YOU FOR HOLDING THIS HEARING REGARDING NASA'S SPACE STATION PLANNING. OUR WITNESSES TODAY REPRESENT A MIX FROM GOVERNMENT AND THE PRIVATE SECTOR. I AM PLEASED THAT NASA IS NOT ONLY STUDYING HOW A SPACE STATION WOULD BENEFIT VARIOUS SCIENCE DISCIPLINES, THEY ARE ALSO STUDYING HOW TO EFFECTIVELY INCLUDE THE PRIVATE SECTOR AND FOREIGN NATIONS.

IN THE PAST, THE UNITED STATES (AS WELL AS THE SOVIET UNION) HAVE EACH PURSUED THEIR OWN UNIQUE MANNED SPACE PROGRAMS. IT HAS ONLY BEEN IN THE RECENT PAST THAT THE RUSSIANS HAVE INVITED COSMONAUTS FROM OTHER SOVIET-BLOC NATIONS TO FLY ABOARD THE SALYUT SPACE STATIONS, AND MOST RECENTLY A FRENCH SPACIONAUT, JEAN-LOUP CRETIEN, VISITED THE SALYUT-7.

THE SPACE SHUTTLE REPRESENTS A TRULY INTERNATIONAL EFFORT. THE REMOTE MANIPULATOR ARM WAS BUILT BY THE CANADIANS, THE SPAS FREE-FLYING PAYLOAD WAS DEVELOPED BY THE GERMANS, AND A NUMBER OF SATELLITES AND SPACE-BORNE EXPERIMENTS HAVE BEEN DEVELOPED BY AND FOR A HOST OF OTHER FOREIGN COUNTRIES.

I AM EXTREMELY PLEASED TO SEE THAT WE ARE PURSUING THESE SAME INTERNATIONAL ACTIVITIES FOR THE SPACE STATION. SEVERAL EUROPEAN COUNTRIES, JAPAN, AND CANADA ARE ALL STUDYING THEIR REQUIREMENTS FOR A PERMANENTLY MANNED SPACE FACILITY. I APPLAUD NASA IN THEIR EFFORTS TO INCLUDE FOREIGN NATIONS AND THE PRIVATE SECTOR IN THE SPACE STATION PLANNING.

THANK YOU, MR. CHAIRMAN.

Mr. VOLKMER. At this time, I will recognize the gentleman from California, if he has any statement he would like to make at this time.

Mr. BROWN. No statement.

Mr. VOLKMER. Without objection, we will permit use of television cameras and still photos during the session.

At this time, I will recognize Mr. Hodge. You may proceed with your testimony.

STATEMENTS OF JOHN D. HODGE, DIRECTOR, SPACE STATION TASK FORCE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY ROBERT F. FREITAG, DEPUTY DIRECTOR, SPACE STATION TASK FORCE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; AND KENNETH S. PEDERSEN, DIRECTOR, INTERNATIONAL AFFAIRS DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. HODGE. Mr. Chairman, it is a pleasure to be here again. I want to thank you for the opportunity to brief you on the status of NASA planning.

I have submitted a rather comprehensive set of viewgraphs for the committee and, in the interest of time, what I'll do is cover some of those. You have the others already, and can ask questions about that subject as we go through.

I have with me today Captain Freitag, who is the Deputy Director of the NASA Space Station Task Force; and Ken Pedersen, who will talk to you about the international aspects of our planning for the space station.

Can I have the first viewgraph?

Mr. VOLKMER. Hit some lights.

[Slide shown.]

Mr. HODGE. The beginning (figure 1) of the space station task force and the intensive effort that we started on planning began after the first four shuttle flights were completed. Here we were with an operational shuttle and an opportunity to start to look at the next step beyond the shuttle. As you know, Mr. Beggs had stated in his confirmation hearing that he felt that the next logical step was the space station, and we proceeded from that point to focus in on the planning activity.

[Slide shown.]

Mr. HODGE. I would like to make three key points (figure 2) about what we've been doing. What we have underway is a modest planning activity within the Agency. It is a planning activity. We have not yet asked for a program. We are beginning to try to understand what a space station is, what it does, and what its impact will be.

We think it is extremely important that we spend a long time, relative to what we have done in the past, on the definition of a space station. This is a serious decision, and we think that we should understand the program well before we submit such a proposal to the executive and to the legislative parts of this Government. This decision has to be made in an orderly and an informed way. And the purpose of our planning activity is to allow that information to emerge so that informed decisions can be made. In ad-

dition to that, Mr. Reagan, our President, last year on July the 4 issued a national space policy, and what we are doing is consistent with that. The subject, fundamentally, is leadership, and we are looking for a leadership program that involves a permanent presence in space, and understanding that term, "permanent presence."

[Slide shown.]

Mr. HODGE. It is important for us to recognize that when we made the decision in the early 1970's to go ahead with a shuttle program, then, in fact, at that time, we thought in terms of a routine access to space. And that was a combination of both the shuttle, the transportation system, and the space station itself. It is apparent that that same decision—that same decision had to be made in the Soviet Union (figure 3). And it is also apparent that they decided, probably because of a lack of technology, that they would go ahead with the space station rather than the shuttle. What that has resulted in, is us having a very good capability to provide routine access to lower Earth orbit through the shuttle system, which has been extremely successful. Whereas, what they have done is begun to understand man's role in space with a very, very extensive set of capabilities over the last 10 years.

I am not saying that we should be reactive, just that we made a different decision 10 years ago, and now it is up to us to decide whether this kind of a step is the right one for us.

[Slide shown.]

Mr. HODGE. It is important to recognize that a space station (figure 4), as we see it right now, should, of itself, be useful. We believe that the first capability, whatever that is, will provide a significant ability for the United States to do things in low Earth orbit. But, I think it would be remiss of us not to look to the future. And as we look at the potential for the space program over the next 25 to 50 years, and we start to install this infrastructure in low Earth orbit, we should think in terms of its ability to make possible future missions as we can take those steps and our capability becomes available. We can return to the Moon; we can go to Mars; and we can send things to geosynchronous orbit.

What we want to do is to make sure that, as we look at all potential futures and regress back to the time when we will have a space station in orbit, that it is possible to evolve that system in terms of those future missions. What we have found is that, no matter what the future of space is, as we look at what we should do next, the space station becomes a part of that need, that capability.

[Slide shown.]

Mr. HODGE. It is important that I describe to you what we mean by a space station (figure 5). I think if you ask the public at large, and quite possibly most of the people within NASA what a space station was, they would think in terms of the movie that came out 15 or 20 years ago, "Odyssey 2001." That was a very large rotating vehicle with 100 people in it and artificial gravity, and so on, and that was thought of as a space station. We believe that a space station is, in fact, many things. We can see that there are things that cannot be properly done with man present in the vehicle. On the other hand, there are things that cannot be done without man present. So, conceptually, we see the space station as both a

manned element and unmanned elements, co-orbiting so that they have access to each other.

The manned base would have the things that you would expect—somewhere to live, somewhere to work, somewhere to do things, somewhere to operate the station itself—and an ability to expand as the capability requirements expand during a decade.

In addition to that, we see the need for large unmanned platforms, either single-purpose platforms, such as a space telescope, which is already under construction, or platforms which contain multiple instruments. We believe that you can reduce the cost of being in space by agglomerating some of these instruments on larger platforms. What you need then is the ability to go backward and forward between the manned element and the unmanned elements. That is a sort of a mini-transportation system, either with direct involvement with astronauts through EVA or with a propulsion system which will take you backward and forward between the various parts of the system.

And, of course, later on, a large high-energy upper stage which will allow you to go from that transportation base to the higher-energy orbit such as geosynchronous or back to the Moon or to Mars, whatever it is you want to do.

[Slide shown.]

Mr. HODGE. The other point (figure 6) that needs to be made is that these things do not actually fall into a single inclination. Where you are most concerned with reducing the cost to orbit, you go in the most efficient mode, which is at low inclination. That is a due East launch out of Cape Kennedy. And associated with that, you would find most of the commercial missions, particularly the materials processing, and so on. The astronomy platforms naturally go into those, although some of them also go into the high inclination.

The second inclination which systems naturally fall into are Sun-synchronous or polar orbit. And there, mostly, you will put platforms which agglomerate instruments which look at the Earth, because that is the only way you can cover the Earth 100 percent.

There is a potential for some missions at inclinations around 60°, but we think that, during the decade, 1990's, that the majority of the missions that we have to perform will fall into one or other of these inclinations. What that tends to mean is, as you look at the total requirements, that we will very likely have a system at low inclination and, either concurrently or later, a system at polar orbit.

Next, please.

[Slide shown.]

Mr. HODGE. I guess the point I want to make here is the space station (figure 7) is not a single thing—it is many things. And what we are trying to do is take advantage of the capability of unmanned systems and manned systems. There has been a tendency for the discussions and the debate over the last year to concentrate on whether we should have a man, or should he be replaced by unmanned systems. It's become a manned versus unmanned debate. We believe that that is the incorrect debate.

What we have to do is to make sure that we have a proper mix between the manned elements and the unmanned elements, where

the man does the things that he is best capable of, and the unmanned systems do the things that they are best capable of. The challenge that we have during this definition process is to develop that proper mix—use automation where it is appropriate, to use robotics where it's appropriate, and to use man's very special capabilities where that is appropriate.

The next one, please.

[Slide shown.]

Mr. HODGE. In that regard, if you look at the studies (figure 8) that have been done in NASA on space stations—and as you say, they've really been studied now since the beginning of NASA, a period of 25 years or so—those studies have really concentrated on single-purpose type missions.

As we have looked at the requirements over the past year—and for the past year, we have really been concentrating on the why of the space station rather than the what—it is obvious that, unless we build a multifunctional facility, it really is not going to be justifiable. What we see is a facility that has the capability of doing laboratory type of work, man in space—Langley Research Center in space, if you would like—for science and applications, for technology, and for advanced development. We see facilities becoming permanent in space. Somebody was drawing an analogy the other day to the Mount Palomar telescope. It is been there 35 years. Fundamentally, the telescope hasn't changed. The instruments have changed on the telescope, the recording system has changed, our ability to understand what's going on has changed, but it is essentially a permanent facility. And we see permanent observatories in that—in that context. The space telescope has been built in such a way that we can change our focal instruments, we can change our recording devices, we can repair it. And in that respect, it will be a permanent facility in space.

We see the station as the jumping-up point, the way point, for missions that go beyond low Earth orbit. There are significant economic benefits to having space-based reusable upper stages, and using the space station as the base from which to go forward is a sort of collection and distribution center in the transportation world, if you think of it that way. If we are going to have those permanent facilities, they are going to go wrong, and we are going to have to fix them. We are going to have to replenish them with consumables and, therefore, the servicing function is a very important part of this capability. But to go along with that, the things that you put in space have to be built in order to be serviced, and that means that this is a design challenge for the unmanned system as well as the manned system.

There is a potential as the amount of information or the amount of data which is produced by these instruments and by these capabilities increases that we will have to reduce the total amount of data while increasing the amount of information which is transmitted. So there is a possibility that the space station will act as a trans—as a communication and data processing—perhaps one of the most exciting things is the emergence of the commercial prospects in space. I personally believe, and you will hear from Mr. Wood later, that in the next 25 years, we will see commercial ventures in space, and we will see companies making a lot of money

out of space. What we have to do is to provide the catalytic action to allow industry to get into space and make it a routine business.

Despite the fact that when we first built the shuttle, people were saying that the payload bay was too big, that we were putting too much lift capability into it, we are already beginning to discover that some of the assets that we want to put into space are larger than the shuttle payload bay. That means that we got to find out how to construct facilities which are larger than that capability. And we believe that the space station itself can be the base from which you do that. That means that we've got to learn a lot about working in space, far beyond the capability we presently have in the shuttle. It must become routine to work outside of the pressured vessel, and we've got to learn how to make things which are larger than the shuttle payload bay in that timeframe.

Finally, if we do all of those things, we're going to have to start to think about very mundane things like logistics and storage. When we have done that, I think that we will have taken that step towards routine operation in space. In many respects, the space program has had an aura of gee whiz for 25 years. And I think it is time for us to take that next step, when we will, in fact, have occupied space.

Next one, please.

[Slide shown.]

Mr. HODGE. Needless to say, you can't go about a planning activity of this kind unless you have some kind of guidelines (figure 9). I meet with Mr. Beggs on a regular basis every week or so, and over the time, we have developed these guidelines that we are using. We believe that it is extremely important that we spend an extended time at the beginning of this program really understanding not only why, but what we're going to do in this program. If we have a very clear specification before we let the hardware contracts, then I think that we can reduce the total cost of the program. In many respects, this is a different way of doing business because often the specifications of a space program of this kind are modified significantly after you let the hardware contract, and that is one of the drives of the cost. We really want to spend this 3-year time up front in order to understand before we let the hardware contract. Now, in many respects, that is leap of faith, because we may end up saying you don't want to do it by the time we've done the definition, and we will have spent a significant amount of money. Five to ten percent of $7.5 billion to $9 billion is not a small amount of money on definition. But I believe that it is extremely important that we do that.

There is a great deal of capability in NASA across the Agency. There has been a tendency in the past for programs which are associated with man to be concentrated in one or two of the centers. What we have done here in order to bring in the expertise of the unmanned program together with the manned program is to take advantage of the capability across the Agency. And we now have all centers participating in the definition process.

We have to set ourselves a time schedule. And as we've looked at the potential missions to be performed during the 1990's, we believe that the sooner we get started, the better. We also believe that the earliest we could have an operating capability would be

1991, and that leaves us with the need for hardware development beginning in 1987. We have now gone through the question of how much will it cost to do that initial capability. And at the moment, I believe, that is of the order of $7.9 to $9 billion. And I will talk a little bit about that later.

[Slide shown.]

Mr. HODGE. The other important thing, and some criticism that NASA has received over the last several years, is whether or not we are user friendly in the systems that we build. Do we make it easy for people to get into space, particularly commercial people? What we have done so far during this last year is involve the user community to the largest extent possible. We intend to continue to do that throughout the program. We believe it's important that the user community buy into the process continuously throughout the design phase. We're not just going to ask them what they want and then go away and design a space station. They will be intimately involved in the design process over the next several years. And finally, the question of international participation--a tricky one, something that we have to work at very hard, and Mr. Pedersen will talk to you about that later.

From an engineering standpoint, we believe that the facilities should be continuously habitable. That means that we should be able to accommodate man in the manned element all the time. Now as to whether it is necessary for him to be there all the time is something we haven't decided. And that really is an engineering decision with regard to whether the system can operate on its own without a man present. We are using the shuttle as the transportation system. It will consist of both manned and unmanned elements.

Perhaps the most important thing in the program—and I will talk to this later—is the question of evolution. We do not believe we should build a dead-ended program. It should be capable of evolution from the very first day to whatever capability we want by the end of the century. Associated with evolution is the whole question of maintainability. Fundamentally, we have built systems which last for the duration of the mission. What we now have to look at very carefully is how do we build systems which can be modified and prepared and changed on orbit. That is a great challenge from a technology standpoint. We want to reduce the cost of operations in space. In many respects, what that means is making the facilities as autonomous as possible and, by that, I mean that they can operate without extensive ground support.

It must be user friendly. And I use the term "technology transparent," meaning that, during the 10-year period, technology will be enhanced significantly. If you look back over 10 years, the way things have changed, they will change again. And we must be able to take advantage of emerging technologies as they become available, which means we have to design the system so that we change the parts on orbit. Again, we've never done that before.

[Slide shown.]

Mr. HODGE. Let me talk a little about the process (figure 10) that we are going through. It is really a very standard engineering process. We had spent the last year largely working on mission requirements. This is the why. What is it we want to do with the space

station? We aimed at the spring of 1983, of this year, in order to have the first cut of the things that we want to do with such a space station, and we have completed that.

We have spent the last 3 or 4 months looking at architecture. And by architecture, I mean, what are the functional capabilities of the various pieces of the space station. While you are doing that, you have to look at the technology problem. You have to do trade studies to decide what are the appropriate technologies to feed into such a device, and we have to start building testbeds where we can put these technologies in and make the pieces work together, so that when we come to the business of design, we can take the capabilities and the technologies and feed them together, and then make rational decisions about what is appropriate at what time.

In late April of this year, we put together a small group that we called the Concept Development Group, and this is really system engineering at its very top level, the first level of system engineering. What they have been looking at is when you merge the architecture with the technologies, what do you have to do first and how much does that cost. This is where our first cost estimates come from.

Next one, please.

[Slide shown.]

Mr. HODGE. I put this (figure 11) in a sort of carrousel form. We have produced the mission sets over the period of the last year. What we want to come out of this is a program plan. But, we have to go through a number of elements in order to understand that properly. From the mission sets, we develop a functional requirement—that is, what do we want this thing to do in order to accomplish those missions? We then have to decide what the physical capabilities of the space station and its attending elements are in order to meet those functional requirements. From that, we have to split those capabilities out into various architectural pieces—what is this piece going to do and what is that piece going to do?

That leads you to the system definition. The system definition then allows you to make first cost estimates, and then from the cost, you get the budget. When you find the budget is too big, you go back and look at your capabilities and find out what you can do to cut them back.

Mr. LUJAN. You need your arrow back the other way, is what you are saying.

Mr. HODGE. It is a circular process.

What we are going to do over the next year is to go through that process another three times. We went through it once on through the period of May, and that allowed us to write our options paper for the—the Presidential paper that we were asked to do. We wrote that paper. That was the first cut. That gave us the numbers that I told you about.

We are now in the process of going through that a second time, right around that loop, and all of these people involved. And that will allow us to establish our 1985 budget. Assuming that we get a positive decision to go ahead with the next step of the definition phase, we have to go through that circle one more time. And each time, we get a little smarter as we do so. By Christmas, we believe that we will be able to write the first set of proposals to bring in-

dustry on board into the definition process. That will take until October of the following year. And that will give NASA time to go through one more time to establish its management process, its acquisition process and its knowledge of the system, so that we, as a Government agency, can be smart managers of the program as we draw industry into this.

Next one.

[Slide shown.]

Mr. HODGE. Here's what we are proposing for the 1984 budget (figure 12). The authorization has gone through. We now have an appropriation.

By the end of 1984, we hope to have established a firm architecture. That is, what are the various pieces of the space station program and what do they do? We also want to know where the tall poles in the tent are with regard to technology, which areas we have to push hardest by the end of 1984. We will have our management plant, particularly the assignments of the individual centers and the relationship between the program office and headquarters and the centers themselves. That's a very important piece. This is not going to be an easy program to manage, because it does have a lot of component parts. We will have a clear plan for participation with DOD at that time—not that we have not been working with DOD. It has really been a very close relationship for the last year. But we need to understand what the various responsibilities are. We will have an international strategy, and we will have an in-house preliminary definition, a starting point to bring industry on board in a very aggressive way.

Acquisition and management strategy are going to be important if we are to reduce the costs of operating in space. And I personally believe that we can do that. Finally, it is important that we continue to keep the user involved. And we will have a significant user development plan by the end of 1984.

[Slide shown.]

Mr. HODGE. I have assumed, of course, that we have a positive decision to go ahead with the 1985 budget process by that time.

To give you an idea (figure 13) of how that schedule lays out, we have our first time phased mission sets for missions in May of this year. We want to have our preferred option for architecture, although we will still have some openings on that until next October or November of this year. We will have a set of program description documents by the end—by fall of this year. By the fall of next year, we will have the advanced development program—this is the question of testbeds and the technology options.

International participation is such that we need a strategy for participation by the end of this year, and really a move toward commitments the following year. I think it's important that we understand how our international partners are going to participate in this before we go into the heavy industrial design process.

We will continue with our trade studies throughout the year. As a matter of fact, they will continue throughout the program. But the majority of the key ones should be finished within the next year. We have to have our program planning—at least in its essence, how are we to proceed—ready by end of January, and we

will have the user development program in place by October of 1984.

[Slide shown.]

Mr. HODGE. Let me tell you something about the process we went through after the first year, when we received the results of the mission analysis studies and the in-house work that is done with regard to mission sets (figure 14).

What we did was to take the people who had been managing this effort down to Langley in a sort of retreat. We had 42 people down there 2 weeks in May, from the 6th to the 13th. They included industry. Although the mission analysis studies had been completed by then, we invited industry to come in, and we tried something a little different here.

We had a panel of key people from the industrial participants who critiqued the NASA work. This is an opposite view to what you normally view. The Government usually brings contractors on board and, when they finish their job, they critique what the contractors did. We felt it would be appropriate to bring them in to critique what we did during this period, and it worked very, very well. I'm trying to allow industry to participate as much as possible in this process. And they did so in here, and I was very grateful to get the criticisms that came in place. They were positive criticisms, I would say. We had the U.S. Air Force involved in that process. And, of course, we had the various NASA working groups. They produced a set of realistic missions that are likely to take place during the 1990's, and they concentrated on science and application, commercial, and technology development missions. We have a data base for that mission set now, and we will modify that set as the use of development plan continues.

Now what they did was to send that set to this concept development group, which we had in place at the same time, and they looked at what had to be built in order to meet those mission sets. Needless to say, the first time you go through that, the requirements for the thing are far in excess of what the potential fiscal capability is going to be. So, these two sort of back off against each other, and they did that over the period of about 2 weeks. What they came out with as being acceptable was a small manned station at 281½°, with a high power level of 55 kilowatts. This was quite in excess of what we had expected, quite frankly, and may be one of the biggest challenges we have technologically. It had pressurized volume of 120 cubic meters, which is about two full space labs in size, just to give you a feel for it. The data rate was 100 megabits per second, which is well within the capability of the TDRSS, just to give you a feel for that—it's about one-third.

A crew of six. It needed a teleoperated maneuvering system to go between the manned and unmanned elements. The manned base had the capability to mount experiments on the outside to the tune of about four very large experiments. We believe that we should put a polar platform in to cover the Earth resources part of the program, but that it was not necessary at this time, in the initial increment, to put a manned element in the space station program at that high inclination orbit. The servicing requirements for that platform were such that it could be done with the shuttle, as it presently is, flying out of Vandenberg. In the 5-day period, we felt

that anything that needed to be done to that platform could be done. There is a question of whether some minor extension in the stay time of the shuttle would be needed for that particular part of the mission.

Next slide.

[Slide shown.]

Mr. HODGE. As I say, there were 107 (figure 15) kinds of missions that came of that, in science and applications, in the commerial area, and in the technology development area. I should say this is a new thought, this whole question of technology development—of having a laboratory in space where you can do research is really a very exciting one to us. We believe that, in the long run, we'll be able to reduce the cost of maturing systems to be flown in space by operating them in space before they are qualified. There are a great many missions of this kind, and eventually become applications, and eventually commercial applications.

[Slide shown.]

Mr. HODGE. From a space science and applications point of view (figure 16), there are really four missions that seem to make sense, and the science and applications community, including Dr. Edelson, who is the A.A. for OSSA, has brought in this very heavily. He is very enthusiastic about this.

You have, first of all, the accommodation on board the manned element. And the particular missions that you're talking about there which are enhanced or enabled are an extensive life science capability and a materials processing capability. We have found that you must have manned interaction for very long periods of time in order to enhance the state-of-the-art, the state of the science, beyond what it is right now. We do need unmanned platforms, particularly because of the contamination and pointing requirements. There will be a need for serving and construction of single-purpose satellites and multipurpose satellites, as well as satellites at geosynchronous orbit. And we must have that transportation mode in order to more economically get payloads to geosynchronous and beyond.

[Slide shown.]

Mr. HODGE. I should say the one we did in working this exercise up was look, first of all, at how we would accommodate all of the potential missions for the 10-year period. So we sort of designed the 2000 space station, and then backed away from that and said what makes sense for the first piece with criteria, like it had to be useful from the very beginning, but it had to be evolveable over the period.

What we came up with in the first cut (figure 17) was the station that had a crew of 6 to 8; power of 60 KW; with the ability to put some attached payloads—four or five was the number we used—with an R&D module of about 120 cubic meters; a satellite servicing capability; the TMS, which we assumed is going to be built associated with the STS, with the shuttle program, needs a smart front end, something which you can manipulate things from, and we intend to add that to it; and a data system which will accommodate up to the 300 megabits per second. That is about the capability of a TDRSS right now.

As far as platforms, we suggested two of them—one at low inclination for the astrophysics program, and one at high inclination for the Earth resources program.

In the initial increment, we did not believe it was appropriate to have a space-based OTV or a manned polar station. As you move toward the end of the century, you essentially double the size of the facility and triple the size of the power. Even so, the data rate is probably still consistent with the TDRSS.

We have left open the question of whether you need a manned polar station by the end of the century, but we very definitely need a spaced-based OTV. That sort of gives you the results of the first time around that carrousel that we talked about.

[Slide shown.]

Mr. HODGE. It would be wrong of me not to tackle the technology issue (figure 18). There is an assumption that we can build a space station right now with the technology we have available, and that is true; and it will be a deadended program. There are technologies of a kind that we have not tackled before, and it is very important that, during the definition process, we bring these technologies along to maturity so that we can use them in the first element. We've got to learn about in-space operations, about long-life systems. We are talking about 15 and 20 years here. We are talking about increasing human productivity.

We are talking about the whole evolutionary process. How do you keep this thing working for that time? We are talking of being a utilitarian system. We are talking about being autonomous from the ground. Maintainability and automation are things that we want to move along. These are technologies of a kind that we really didn't discuss before. We're not talking about high performance systems, we are talking about systems which are going to last a long time, and which can be repaired.

[Slide shown.]

Mr. HODGE. In order to do that, we need to test those systems first on the ground in testbeds (figure 19). We have to feed them with new pieces of technology and test them together. And we have started to put this plan together now. It will be in operation by the end of 1984, fiscal year 1984.

[Slide shown.]

Mr. HODGE. Another thing that is going to be important is that many of these systems must be tested in the shuttle system before we commit them on the space station (figure 20). And we are now putting an aggressive program together for the testing, flight testing, of those new systems in the shuttle. This really is an enormous capability for us, as the shuttle matures and we can put these—these flight tests in on the margin. As we do other things with the shuttle, we will be able to have a greater confidence in the selection of technologies as we make them for the design of the space station.

[Slide shown.]

Mr. HODGE. Where are we now (figure 21)? We have all of the centers participating. We have a steering committee which is helping us with the technology. We have the use of communities involved. We have taken a first cut at what this all means. And we

are beginning to understand the necessities of the management process.

When we're through, we want a clearly defined concept, we want a management process that we know will work, we want a detailed design, and we want to have industry on board and working with us. The reason we want to take that deliberate approach to this is so that the systems are well understood, that we know the technology will work, and we have a good understanding of how much it is going to cost. And what that will allow is for the executive and the legislative organizations to make an informed decision about whether we should proceed with the program.

Thank you very much, Mr. Chairman.

[Figures 1–21 of the oral presentation, the prepared statement, plus answers to questions asked of Mr. Hodge follow:]

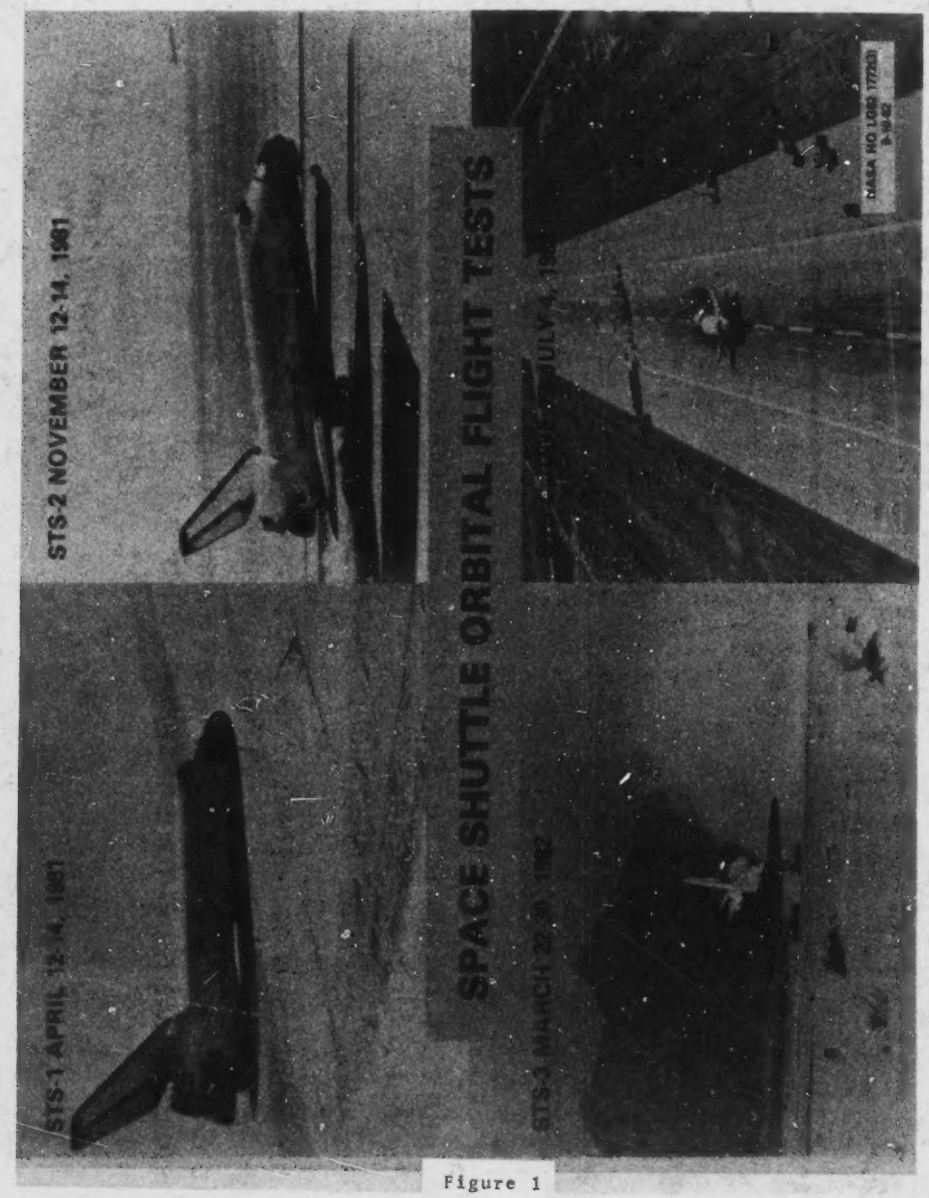

SPACE SHUTTLE ORBITAL FLIGHT TESTS
STS-2 NOVEMBER 12-14, 1981
STS-1 APRIL 12-14, 1981
STS-3 MARCH 22-30, 1982
NASA HQ L82 17720
3-9-82

Figure 1

NASA SPACE STATION DEFINITION

Three Key Points:

- NASA has underway a modest planning effort to define a possible space station.

- Adequate space station definition is essential if Congress and the Administration are to be able to make an informed decision on whether the United States should proceed with a station as the next major national initiative in space.

- Our planning is consistent with and supports the President's National Space Policy in which a key objective is " to continue to explore the requirements, operational concepts, and technology associated with permanent space facilities."

NASA HQ MF83-1424 (1)
3-30-83

Figure 3

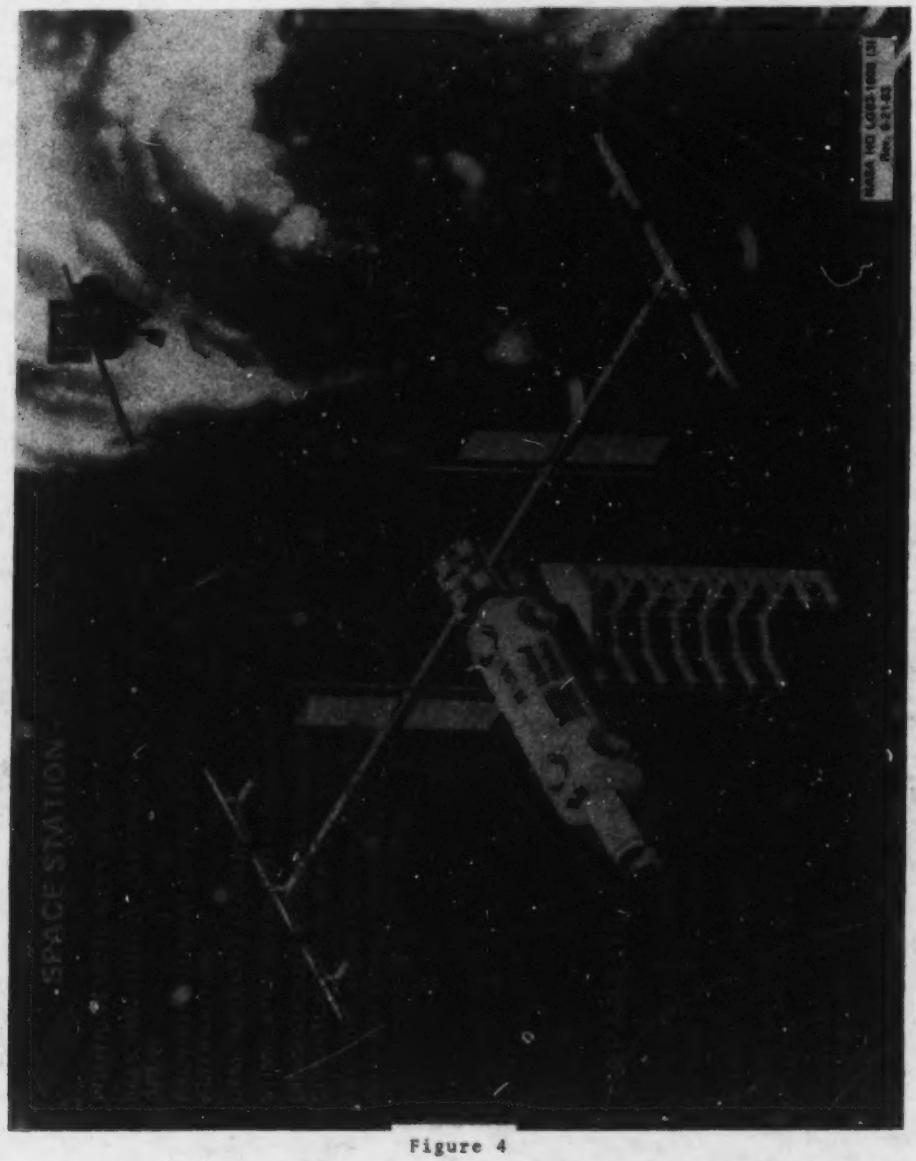
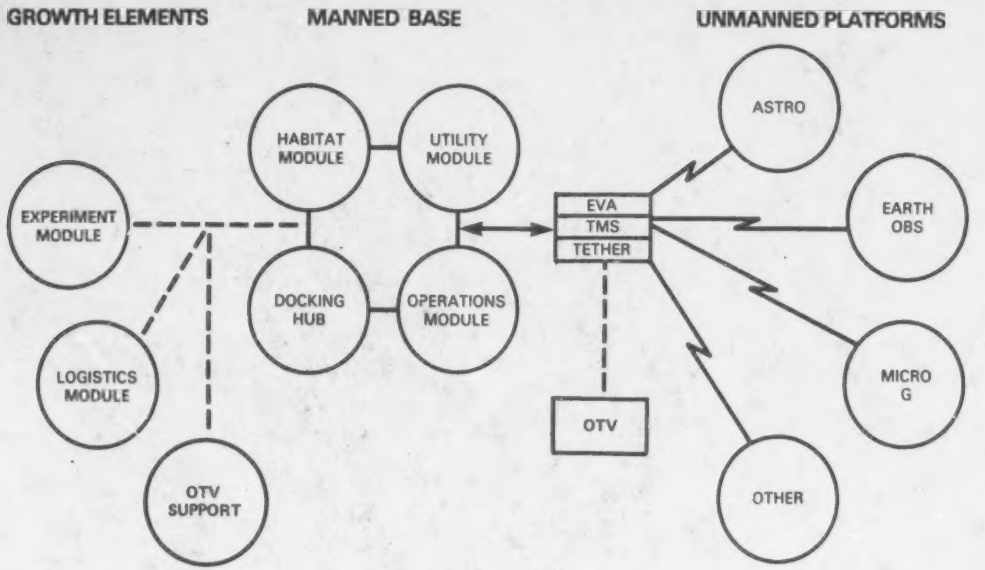


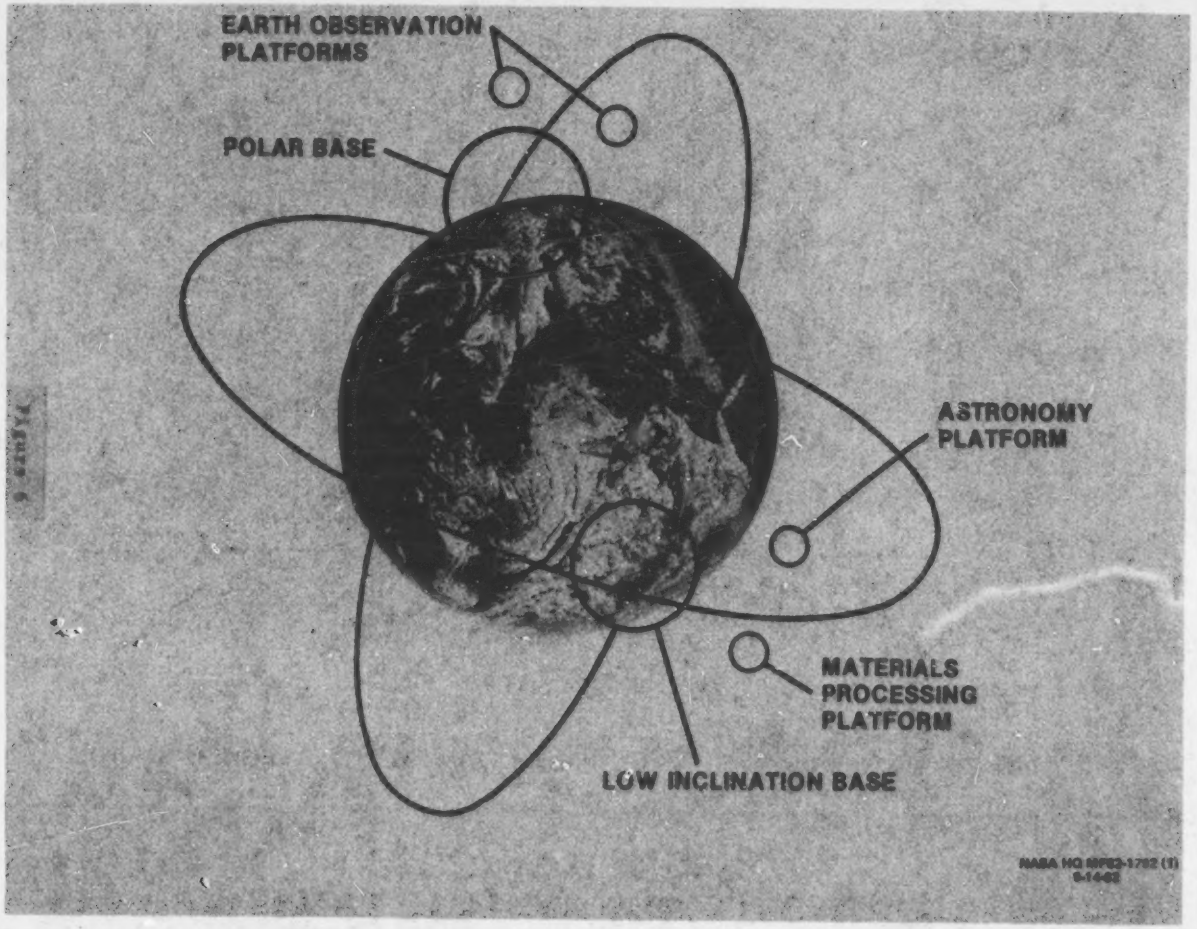
Figure 4

A SPACE STATION ARCHITECTURE: CLUSTER CONCEPT



NASA HQ LG83-130 (1)
REV. 1-12-83

Figure 5


EARTH OBSERVATION PLATFORMS
POLAR BASE
ASTRONOMY PLATFORM
MATERIALS PROCESSING PLATFORM
LOW INCLINATION BASE

MAN IN SPACE
• INTERACT WITH INSTRUMENTS
• MAINTAIN AND REPAIR
• RECOGNIZE PATTERNS/ ZERO TIME LAG
• REACT TO UNEXPECTED:
– OPPORTUNITIES
– DIFFICULTIES
• CAPTURE PUBLIC'S IMAGINATION
GOAL: PROPER MIX OF MAN AND MACHINE

Figure 7

FUNCTIONS OF A SPACE STATION

- On-orbit laboratory
  - — Science and applications
  - — Technology and advanced development
- Permanent observatory(s)
- Transportation node
- Servicing facility
  - — Free flyers
  - — Platforms
- Communications and data processing node
- Manufacturing facility
- Assembly facility
- Storage depot

A space station is a multi-purpose facility

NASA HQ MF83-2423 (1)
Rev. 7-25-83

Figure 8

SPACE STATION PLANNING GUIDELINES

MANAGEMENT RELATED

- Three year extensive definition (5-10% of program cost)
- NASA-wide participation
- Development funding in FY 1987
- IOC in 1991
- Cost of initial capability: 7.5-9B
- Extensive user community involvement
  - —Science and applications
  - —Industry
  - —DoD
  - —Commercial
- Possible international participation

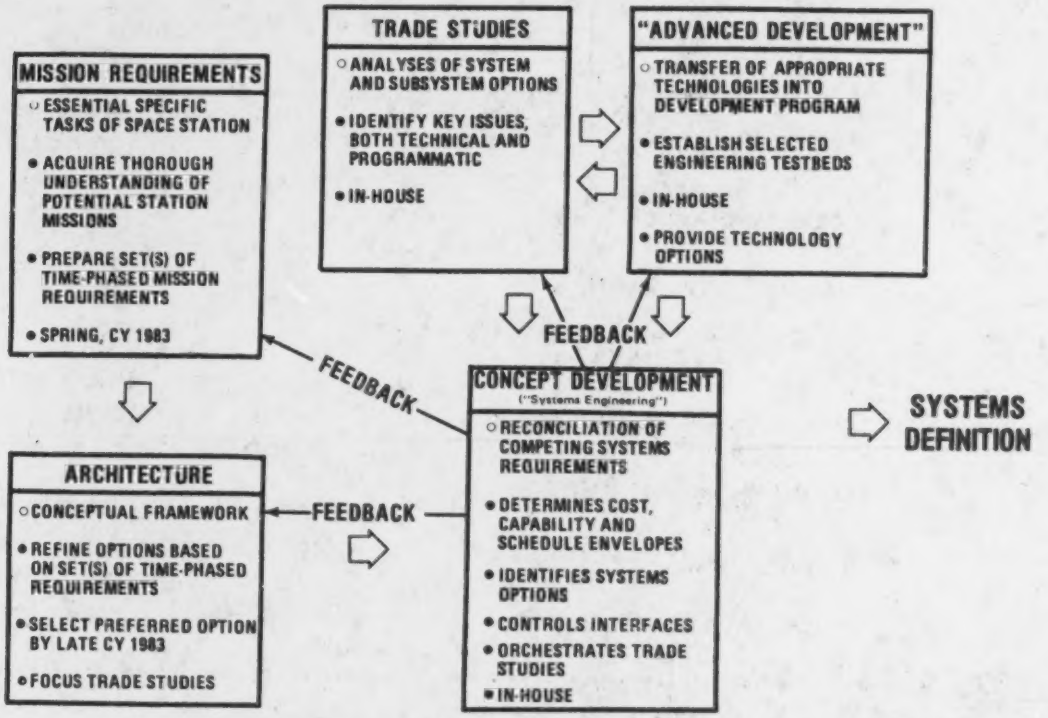
ENGINEERING RELATED

- Continuously habitable
- Shuttle dependent
- Manned and unmanned elements
- Evolutionary
- Maintainable/restorable
- Operationally autonomous
- User friendly
- Technology transparent

Figure 9

NASA HQ MF83-2251 (1)
REV. 6-21-83

SPACE STATION DEFINITION ACTIVITY


MISSION REQUIREMENTS
○ ESSENTIAL SPECIFIC TASKS OF SPACE STATION
• ACQUIRE THOROUGH UNDERSTANDING OF POTENTIAL STATION MISSIONS
• PREPARE SET(S) OF TIME-PHASED MISSION REQUIREMENTS
• SPRING, CY 1983
TRADE STUDIES
○ ANALYSES OF SYSTEM AND SUBSYSTEM OPTIONS
• IDENTIFY KEY ISSUES, BOTH TECHNICAL AND PROGRAMMATIC
• IN-HOUSE
"ADVANCED DEVELOPMENT"
○ TRANSFER OF APPROPRIATE TECHNOLOGIES INTO DEVELOPMENT PROGRAM
• ESTABLISH SELECTED ENGINEERING TESTBEDS
• IN-HOUSE
• PROVIDE TECHNOLOGY OPTIONS
FEEDBACK
FEEDBACK
CONCEPT DEVELOPMENT
("Systems Engineering")
○ RECONCILIATION OF COMPETING SYSTEMS REQUIREMENTS
• DETERMINES COST, CAPABILITY AND SCHEDULE ENVELOPES
• IDENTIFIES SYSTEMS OPTIONS
• CONTROLS INTERFACES
• ORCHESTRATES TRADE STUDIES
• IN-HOUSE
FEEDBACK
ARCHITECTURE
○ CONCEPTUAL FRAMEWORK
• REFINE OPTIONS BASED ON SET(S) OF TIME-PHASED REQUIREMENTS
• SELECT PREFERRED OPTION BY LATE CY 1983
• FOCUS TRADE STUDIES
SYSTEMS DEFINITION

NASA HQ LG83-894 (1)
Rev. 5-24-83

Figure 10

SPACE STATION DEFINITION: APPROACH TO PROGRAM PLAN

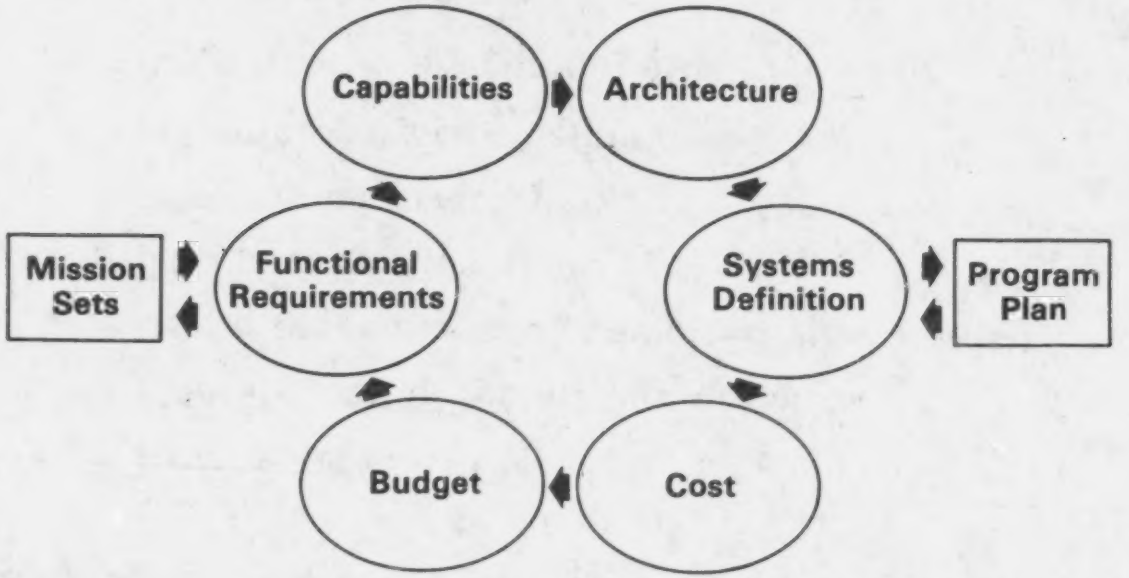


Figure 11

NASA HQ MF 83-2265(1)
6-3-83

FISCAL YEAR 1984 END-ITEMS

- Architecture
- Identification of technology options
- Center assignments on advanced development
- DoD participation plan
- International strategy
- Preliminary system definition
- Acquisition/management strategy
- User development plan

Figure 12

NASA HQ MF 83-2344(1)
6-3-83

Space Station Planning In 1983 And 1984

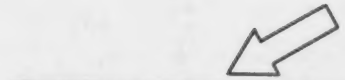
ACTIVITY	END-ITEM	DATE
Mission Requirements	Time-phased Mission Set(s)	May, 1983
"Architecture"	Preferred Option, Plus Alternatives	Nov., 1983
Program Description Documents	First Edition of Documents Published	Oct., 1983
Advanced Development	Testbeds in Place	Fall, 1984
Planning for Potential International Participation	Strategy Agreed to	Nov., 1983
Trade Studies/Systems Engineering	Preliminary Systems Definition	Oct., 1984
Program Planning	Development, Operations, and Utilization Plan in Place	Jan., 1984
User Development	User Involvement Plan in Place	Oct., 1984

Figure 13

NASA HQ L83-946 (1)
Rev. 3/4/83

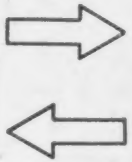
SPACE STATION DEFINITION: MISSION SYNTHESIS WORKSHOP

- MAY 6-13, 1983
- LANGLEY RESEARCH CENTER, VA
- 42 PARTICIPANTS
  - INDUSTRY
  - USAF OBSERVERS
  - NASA



TIME PHASED MISSION SET

- 107 MISSIONS (1991-2000)
- REALISTIC
- IN FIELDS OF:
  - SCIENCE AND APPLICATIONS
  - COMMERCIAL
  - TECHNOLOGY DEVELOPMENT
- COMPUTERIZED DATA BASE FOR EACH MISSION
- REDUCED MISSION SET
- "MINIMUM ACCEPTABLE" MISSION SET



BASELINE REQUIREMENTS

- FOR STATION AT 28.5°
- USER POWER: 55 KW
- USER PRESSURIZED VOLUME: 120 M^3
- DATA: 100 MBPS
- CREW: 6 (5 FOR PAYLOAD OPS.)
- TMS SERVICING
- MOUNTS: 4-6
- PLUS POLAR PLATFORM:
  - 12.5 KW
  - 4 MOUNTS
  - 300 MBPS

NASA HQ MP83-2239 (1)
Rev. 7-25-83

Figure 14

SPACE STATION DEFINITION
PRELIMINARY MISSION DATA BASE (1991 - 2000)

SCIENCE AND APPLICATIONS

Astrophysics	22
Earth Science and Applications	5
Solar System Exploration	10
Life Sciences	6
Materials Science	4
Communications	1
	(48)

COMMERCIAL

Materials Processing in Space	11
Earth and Oceans Observations	3
Communications	14
	(28)

TECHNOLOGY DEVELOPMENT

Materials and Structures	5
Energy Conversion	3
Computer Science and Electronics	4
Propulsion	2
Controls and Human Factors	5
Space Station Systems/Operations	8
Fluid and Thermal Physics	4
	(31)

TOTAL 107

Figure 15

NASA HQ MF83-1977 (1)
Rev. 6-24-83

SPACE STATION DEFINITION
SPACE SCIENCE AND APPLICATIONS POTENTIAL UTILITY OF A SPACE STATION

ON-BOARD ACCOMMODATION

- Life sciences
- Intensive man-interactive investigations (e.g., mps)
- Other (e.g., Cosmic Ray)

PLATFORMS

- Contamination
- Orbit requirements

SERVICING AND CONSTRUCTION

- Free flying craft already launched
- Co-orbiting platform(s), from station
- Other platforms, from orbiter if not station

TRANSPORTATION NODE

- Geosynch satellites
- Solar system missions

NASA HQ MPSS-1979 (1)
5-11-83

SPACE STATION: FIRST CUT AT CAPABILITIES

	INITIAL	FUTURE
BASE AT 28.5°		
Crew	6 – 8	12 – 18
Power	60KW	160KW
Attached payloads	Some	More
R&D pressurized modules	2 – 3 (120M^3)	4 – 6 (300M^3)
Satellite servicing capability	Initial (close by)	Mature
Smart front-end TMS	Available	Available
Data system	300 MBPS	300 MBPS
PLATFORMS		
28.5°/15KW	One	Several
Polar/15KW	One	One
SPACE-BASED OTV	No	Yes
MANNED POLAR STATION	No	?

NASA HQ MF83-2422 (1)
6-16-83

Figure 17

TECHNOLOGY ISSUES

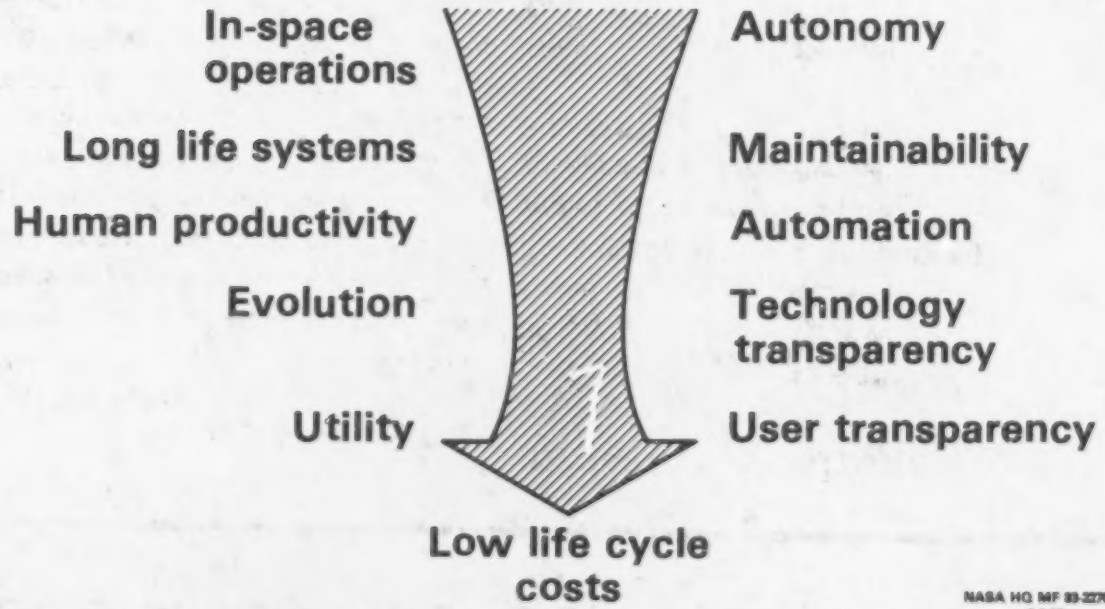


Figure 18

SPACE STATION PLANNING: ADVANCED DEVELOPMENT ACTIVITIES

OBJECTIVES

- develop "test bed" capabilities along major subsystem disciplines to evaluate technology and estimate risk
- provide the "transfer function" for new technology into the space station development program
- provide technology options to program manager
- establish a qualified subcontractor cadre for system implementation

APPROACH

- manage advanced development program at NASA centers
  - implement "test bed" capabilities
  - select technologies for brassboard/prototype fabrication and demonstration
  - coordinate advanced development activities with technologist
  - establish test criteria and procedures
- coordinate closely with OAST technology program
  - provide developer focus to early technology activities
  - ensure compatability in program content and schedule

NASA HQ LG83-175 (1)
Rev. 5-19-83

Figure 19

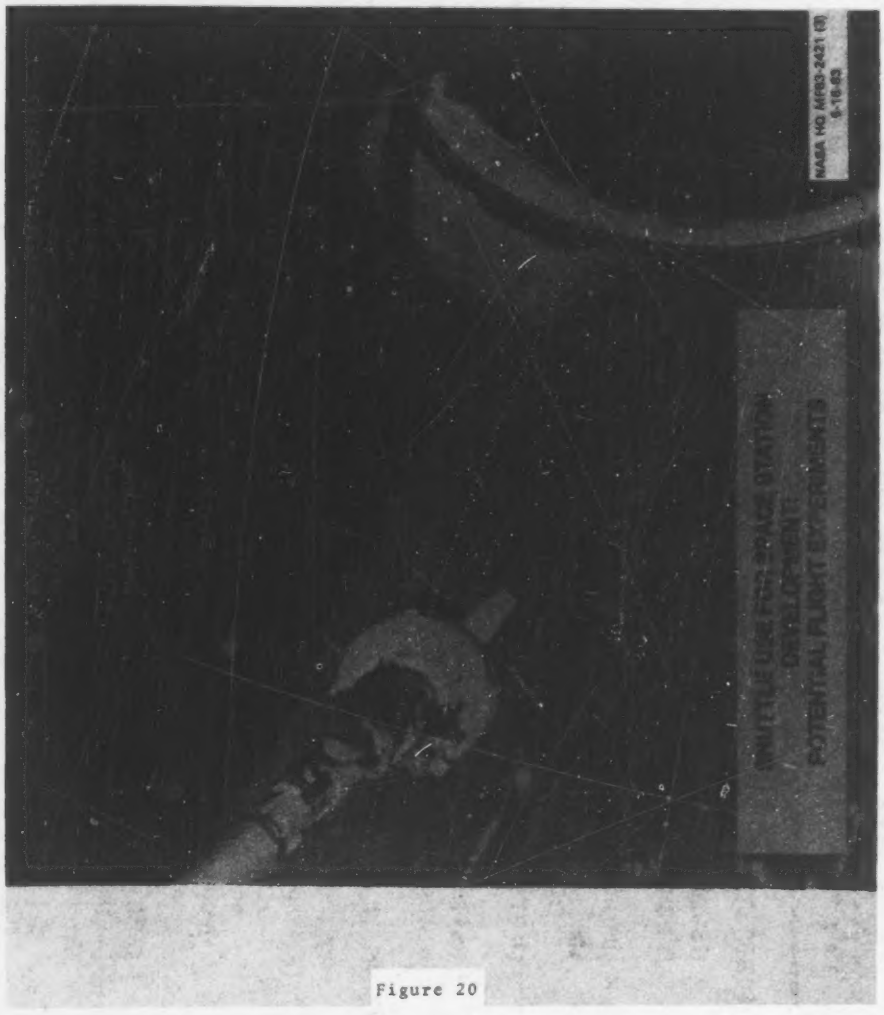

NASA HQ M83-2431 (8)
6-16-83
SHUTTLE ORBITER RENDEZVOUS
DEVELOPMENT
POTENTIAL FLIGHT EXPERIMENTS

Figure 20

SPACE STATION PLANNING: APPROACH TO DEFINITION

NOW	LATER	SO THAT	LEADING TO
• NASA centers on board • Technology Steering Committee at work • User communities involved • First cut of time phased mission sets prepared • Preliminary systems definition and concept development begun • Management approach under consideration	• Concept defined • Mission requirements well understood • Detailed system design carried to subsystem level • Project, development and fabrication, test and operations plans completed • Management plan in place • Industry team selected via competition	○ Systems are well understood ○ Technology is reliable ○ Cost and schedule estimates are real	• Informed decision on the nature of the development program

Figure 21

NASA HQ LG83-494 (1)
Rev. 7-25-83

SPACE STATION DEFINITION ACTIVITIES

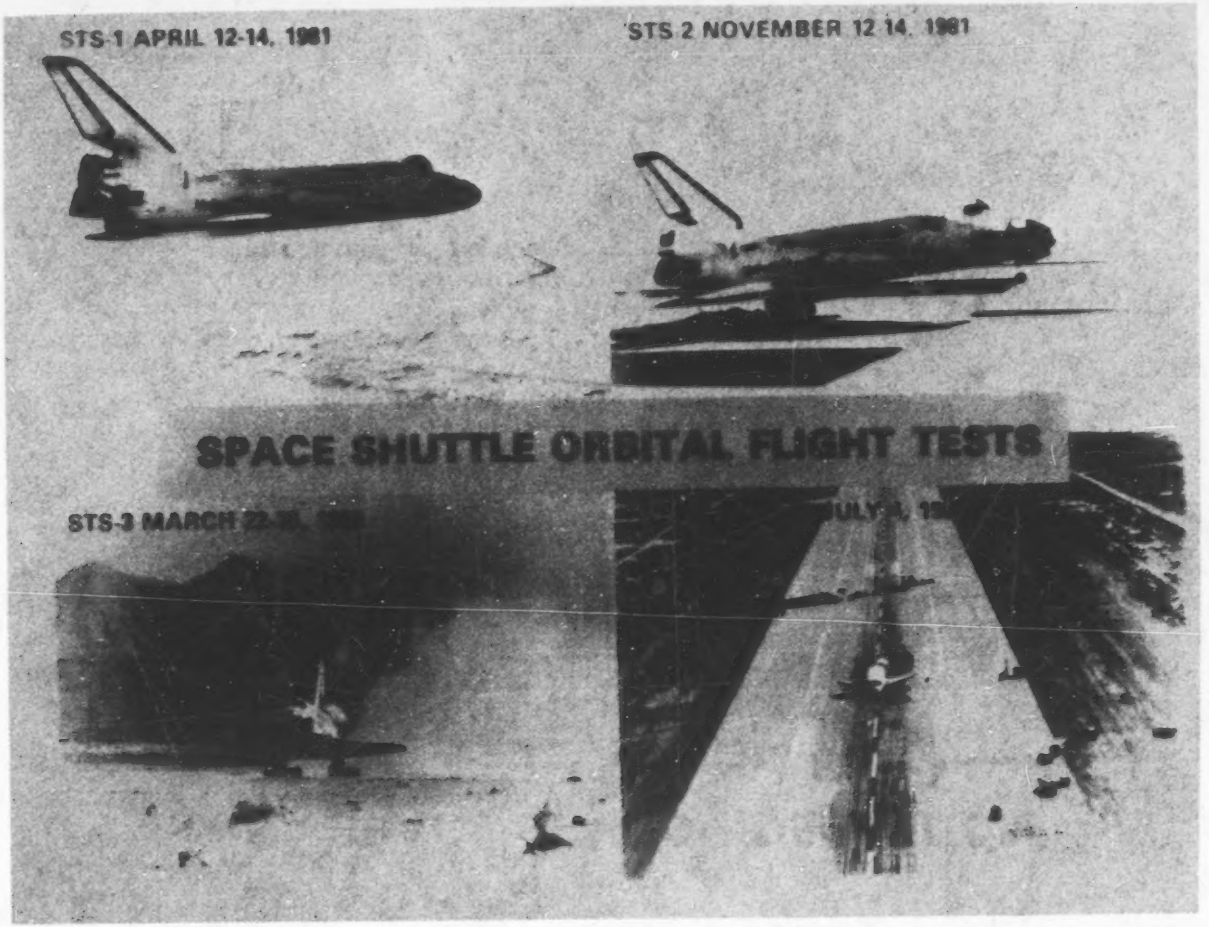
SPACE STATION TASK FORCE

36

AUGUST 2, 1983

National Aeronautics and Space Administration
Twenty-fifth Anniversary
1958-1983

JOHN D. HODGE


STS-1 APRIL 12-14, 1981
STS 2 NOVEMBER 12 14, 1981
SPACE SHUTTLE ORBITAL FLIGHT TESTS
STS-3 MARCH 22-30, 1982

NASA SPACE STATION DEFINITION

Three Key Points:

- NASA has underway a modest planning effort to define a possible space station.
- Adequate space station definition is essential if Congress and the Administration are to be able to make an informed decision on whether the United States should proceed with a station as the next major national initiative in space.
- Our planning is consistent with and supports the President's National Space Policy in which a key objective is " to continue to explore the requirements, operational concepts, and technology associated with permanent space facilities."

NASA HQ MF83-1424 (1)
3-30-83

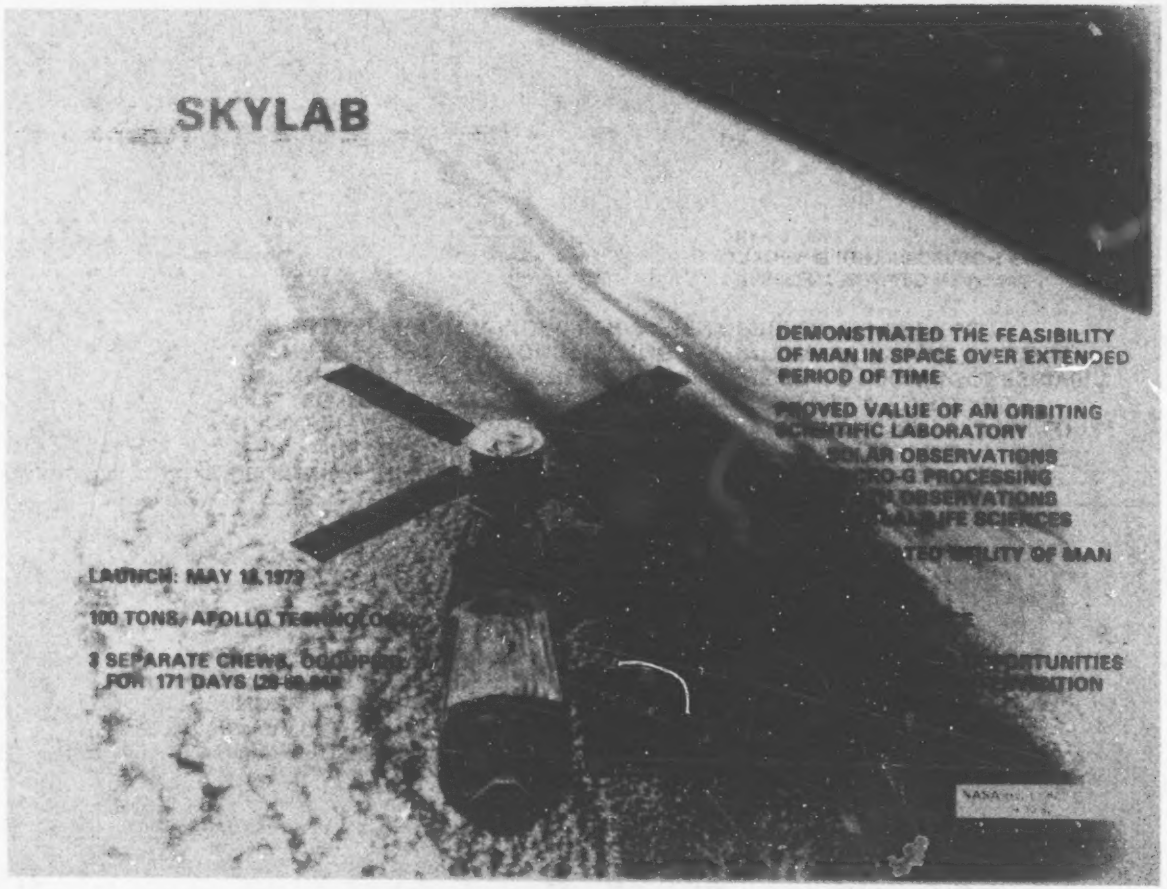
"UNITED STATES GOVERNMENT PROGRAMS SHALL CONTINUE A BALANCED STRATEGY OF RESEARCH, DEVELOPMENT OPERATIONS, AND EXPLORATION FOR SCIENCE, APPLICATIONS AND TECHNOLOGY. THE KEY OBJECTIVES OF THESE PROGRAMS ARE TO.....(3) CONTINUE TO EXPLORE THE REQUIREMENTS, OPERATIONAL CONCEPTS, AND TECHNOLOGY ASSOCIATED WITH PERMANENT SPACE FACILITIES."

WHITE HOUSE FACT SHEET
NATIONAL SPACE POLICY
JULY 4, 1982

"BEGINNING WITH THE NEXT FLIGHT, THE COLUMBIA AND HER SISTER SHIPS WILL BE FULLY OPERATIONAL AND READY TO PROVIDE ECONOMICAL AND ROUTINE ACCESS TO SPACE FOR SCIENTIFIC EXPLORATION, COMMERCIAL VENTURES AND FOR TASKS RELATED TO THE NATIONAL SECURITY. SIMULTANEOUSLY, WE MUST LOOK AGGRESSIVELY TO THE FUTURE BY DEMONSTRATING THE POTENTIAL OF THE SHUTTLE AND ESTABLISHING A MORE PERMANENT PRESENCE IN SPACE."

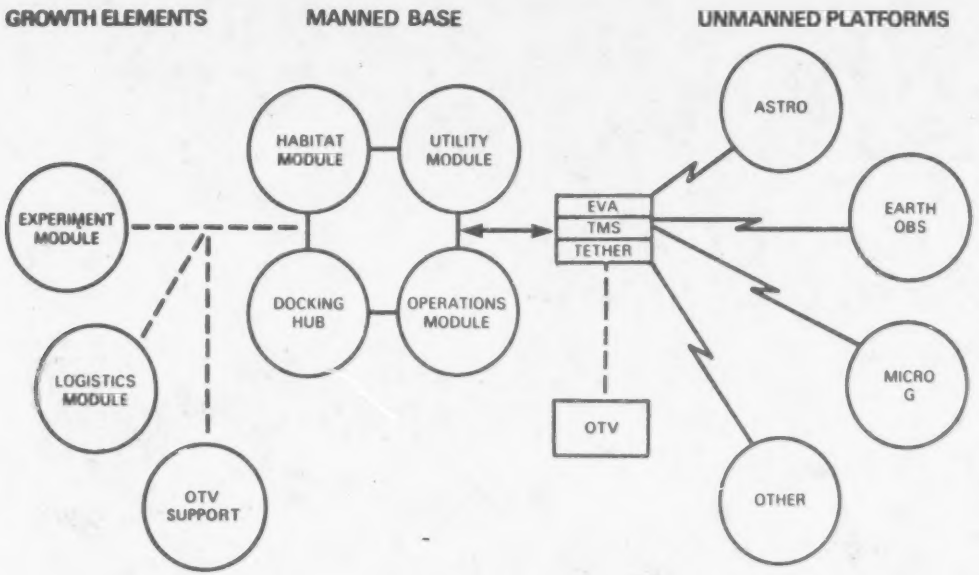
PRESIDENT RONALD REAGAN
DRYDEN FLIGHT RESEARCH FACILITY
JULY 4, 1982

NASA HQ L(83-1722(1)
9-3-82


SKYLAB
DEMONSTRATED THE FEASIBILITY
OF MAN IN SPACE OVER EXTENDED
PERIOD OF TIME
PROVED VALUE OF AN ORBITING
SCIENTIFIC LABORATORY
SOLAR OBSERVATIONS
MICRO-G PROCESSING
OBSERVATIONS
LIFE SCIENCES
LITY OF MAN
LAUNCH: MAY 14,1973
100 TONS/ APOLLO TECHNOLOGY
3 SEPARATE CREWS, OCCUPIED
FOR 171 DAYS (28 DAYS)
PORTUNITIES
NITION

SOVIET *SALYUT*
SPACE STATION

A SPACE STATION ARCHITECTURE: CLUSTER CONCEPT



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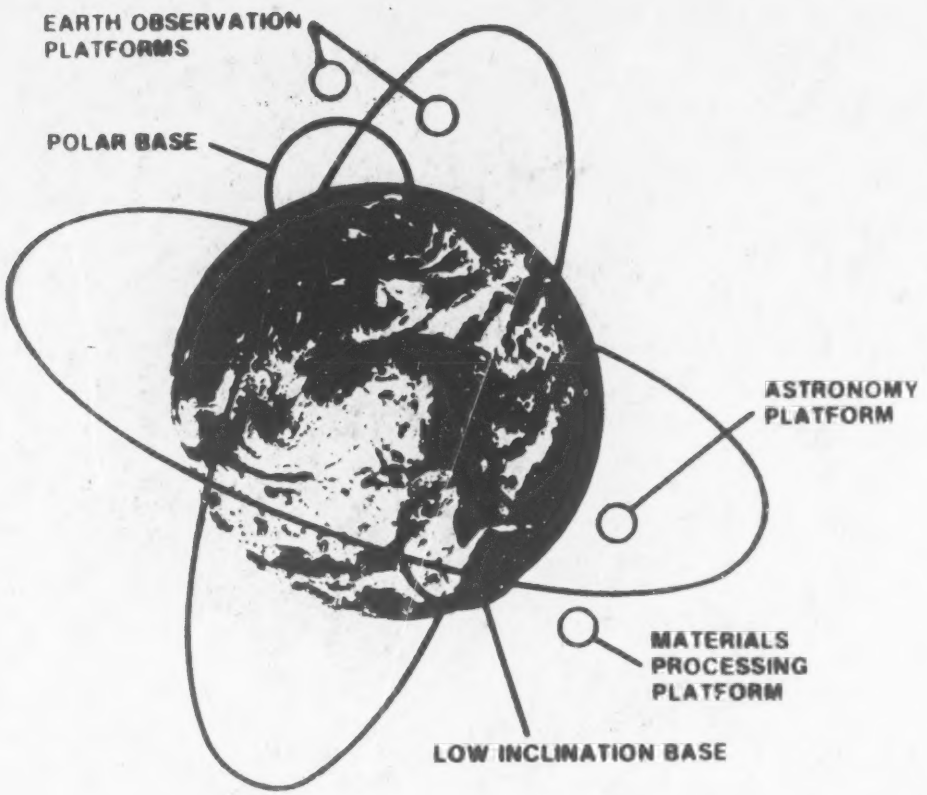
REV 1-12-83


EARTH OBSERVATION PLATFORMS
POLAR BASE
ASTRONOMY PLATFORM
MATERIALS PROCESSING PLATFORM
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MAN IN SPACE
• MAINTAIN AND REPAIR
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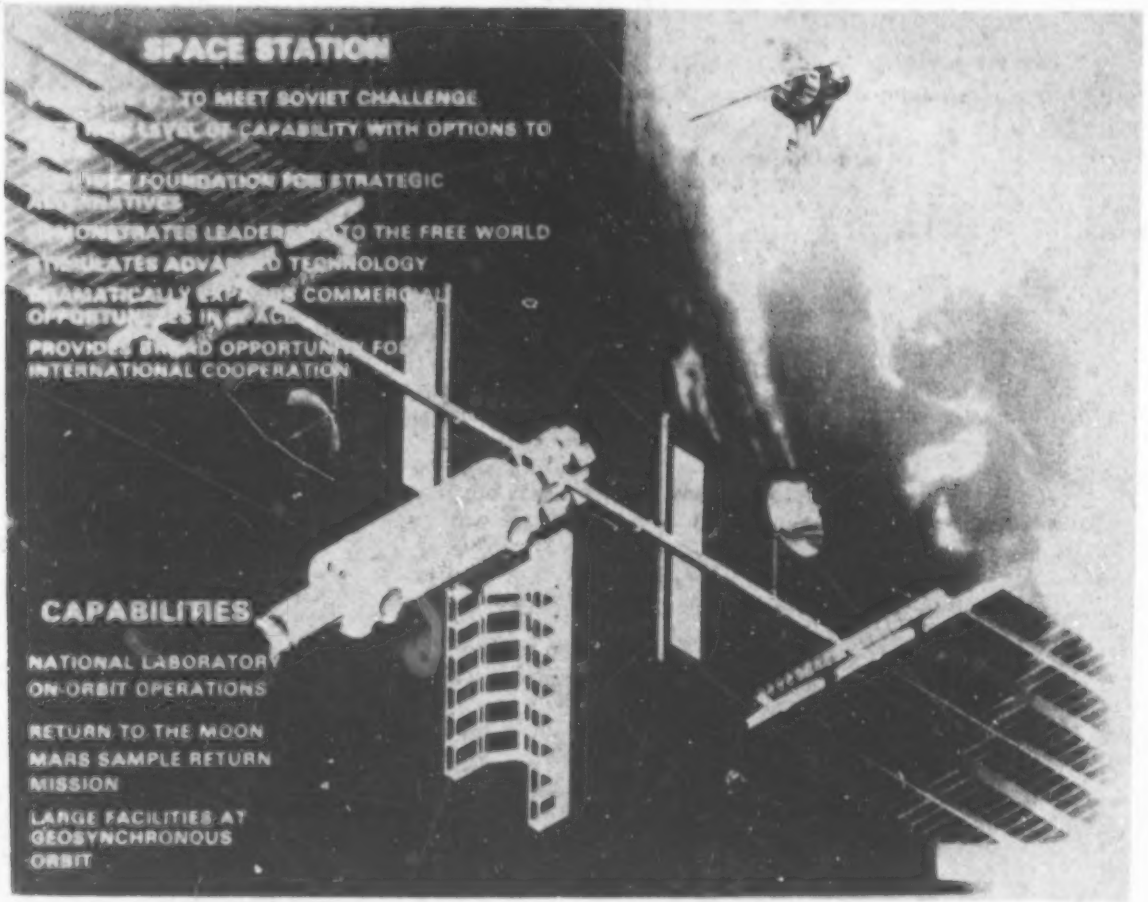
ZERO TIME LAG
• REACT TO UNEXPECTED
OPPORTUNITIES
DIFFICULTIES
• CAPTURE PUBLIC'S
IMAGINATION
GOAL: PROPER MIX OF
MAN AND MACHINE

SPACE STATION-RELATED DEFINITIONS

Space Station	—A totality of manned and unmanned earth-orbiting, interdependent elements.
Base	—A core of modules including facilities for docking, control and human habitation
Element	—Any module, platform or free-flyer which is dependent upon the space station system for its longterm operation
Module	—An attached space station element which provides a unique or common function for system operations
Free-Flyer	—Any free-flying unmanned satellite which is serviced by or otherwise dependent upon the space station system
Platform	—An unmanned, orbiting multi-use structure capable of supplying limited utilities to changeable payloads and dependent upon the space station system for its long term operation
Support	—Ground or space-based operations and equipment which interact with the space station

NASA HQ MFB3-23031(1)
6-3-83


SPACE STATION
TO MEET SOVIET CHALLENGE
LEVEL OF CAPABILITY WITH OPTIONS TO
FOUNDATION FOR STRATEGIC
INITIATIVES
DEMONSTRATES LEADERSHIP TO THE FREE WORLD
STIMULATES ADVANCED TECHNOLOGY
DRAMATICALLY EXPANDS COMMERCIAL
OPPORTUNITIES IN SPACE
PROVIDES BROAD OPPORTUNITY FOR
INTERNATIONAL COOPERATION
CAPABILITIES
NATIONAL LABORATORY
ON-ORBIT OPERATIONS
RETURN TO THE MOON
MARS SAMPLE RETURN
MISSION
LARGE FACILITIES AT
GEOSYNCHRONOUS
ORBIT

FUNCTIONS OF A SPACE STATION

- On-orbit laboratory
  - — Science and applications
  - — Technology and advanced development
- Permanent observatory(s)
- Transportation node
- Servicing facility
  - — Free flyers
  - — Platforms
- Communications and data processing node
- Manufacturing facility
- Assembly facility
- Storage depot

A space station is a multi-purpose facility

NASA HQ MF83-2423 (1)
Rev. 7-25-83

SPACE STATION
PLANNING GUIDELINES

MANAGEMENT RELATED

- Three year extensive definition (5-10% of program cost)
- NASA-wide participation
- Development funding in FY 1987
- IOC in 1991
- Cost of initial capability: 7.5-9B
- Extensive user community involvement
  - —Science and applications
  - —Industry
  - —DoD
  - —Commercial
- Possible international participation

ENGINEERING RELATED

- Continuously habitable
- Shuttle dependent
- Manned and unmanned elements
- Evolutionary
- Maintainable/restorable
- Operationally autonomous
- User friendly
- Technology transparent

NASA HQ MF83-2251 (1)
REV. 6-21-83

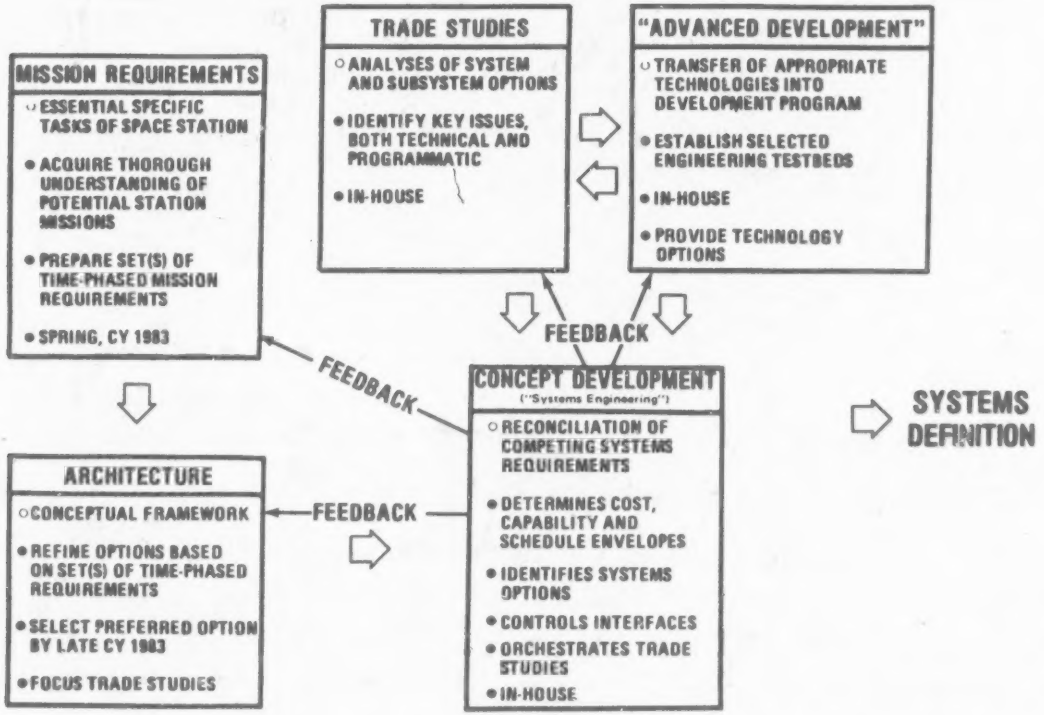
NASA SPACE STATION TASK FORCE

- Established in May, 1982 by the NASA Administrator
- NASA-wide activity: Centers and Headquarters
- Reports to NASA Associate Deputy Administrator

- Provide focus and direction for the agency's space station planning activities
- Define possible space station initiative
  - mission requirements
  - architectural options
  - trade studies
  - "advanced development"
  - concept development ("systems engineering")
- Develop management/acquisition plans

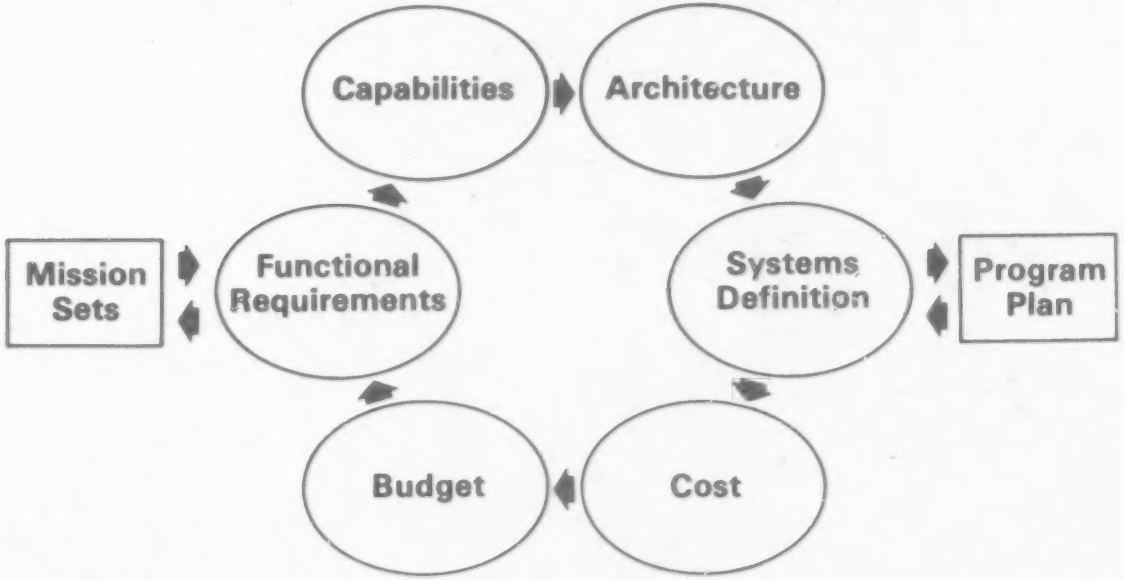
NASA HQ MT82-1157 (1)
Rev. 3-30-83

SPACE STATION DEFINITION ACTIVITY


MISSION REQUIREMENTS
○ ESSENTIAL SPECIFIC TASKS OF SPACE STATION
• ACQUIRE THOROUGH UNDERSTANDING OF POTENTIAL STATION MISSIONS
• PREPARE SET(S) OF TIME-PHASED MISSION REQUIREMENTS
• SPRING, CY 1983
TRADE STUDIES
○ ANALYSES OF SYSTEM AND SUBSYSTEM OPTIONS
• IDENTIFY KEY ISSUES, BOTH TECHNICAL AND PROGRAMMATIC
• IN-HOUSE
"ADVANCED DEVELOPMENT"
○ TRANSFER OF APPROPRIATE TECHNOLOGIES INTO DEVELOPMENT PROGRAM
• ESTABLISH SELECTED ENGINEERING TESTBEDS
• IN-HOUSE
• PROVIDE TECHNOLOGY OPTIONS
FEEDBACK
FEEDBACK
CONCEPT DEVELOPMENT
("Systems Engineering")
○ RECONCILIATION OF COMPETING SYSTEMS REQUIREMENTS
• DETERMINES COST, CAPABILITY AND SCHEDULE ENVELOPES
• IDENTIFIES SYSTEMS OPTIONS
• CONTROLS INTERFACES
• ORCHESTRATES TRADE STUDIES
• IN-HOUSE
SYSTEMS DEFINITION
ARCHITECTURE
○ CONCEPTUAL FRAMEWORK
• REFINE OPTIONS BASED ON SET(S) OF TIME-PHASED REQUIREMENTS
• SELECT PREFERRED OPTION BY LATE CY 1983
• FOCUS TRADE STUDIES
FEEDBACK

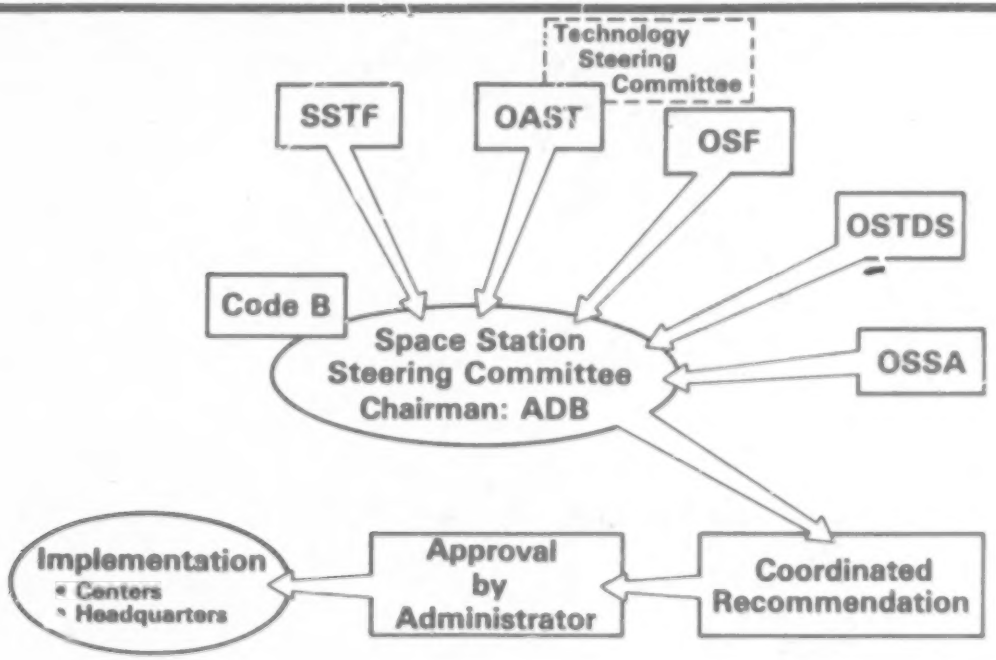
NASA HQ LG83-894 (1)
Rev. 5-24-83

SPACE STATION DEFINITION: APPROACH TO PROGRAM PLAN



NASA HQ MF 83 2265(1)
6 3 83

AGENCY PROGRAM REVIEW



FISCAL YEAR 1984 END-ITEMS

- Architecture
- Identification of technology options
- Center assignments on advanced development
- DoD participation plan
- International strategy
- Preliminary system definition
- Acquisition/management strategy
- User development plan

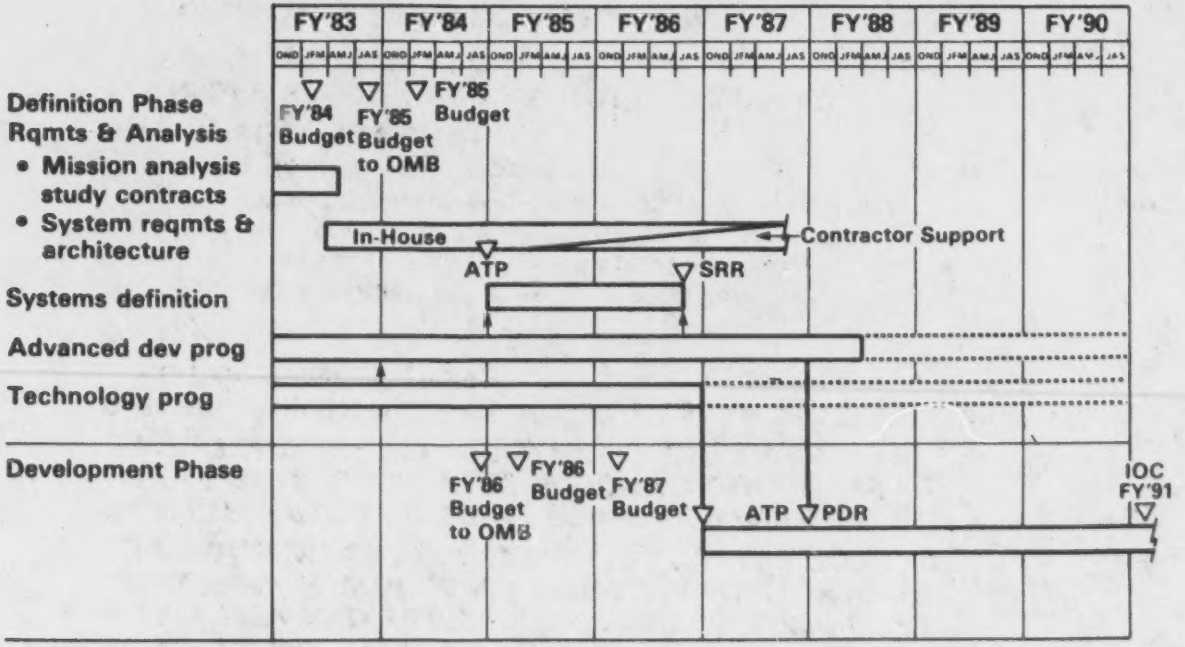
NASA HQ MF #5 254411
6-340

Space Station Planning In 1983 And 1984

ACTIVITY	END-ITEM	DATE
Mission Requirements	Time-phased Mission Set(s)	May, 1983
"Architecture"	Preferred Option, Plus Alternatives	Nov., 1983
Program Description Documents	First Edition of Documents Published	Oct., 1983
Advanced Development	Testbeds in Place	Fall, 1984
Planning for Potential International Participation	Strategy Agreed to	Nov., 1983
Trade Studies/Systems Engineering	Preliminary Systems Definition	Oct., 1984
Program Planning	Development, Operations, and Utilization Plan in Place	Jan., 1984
User Development	User Involvement Plan in Place	Oct., 1984

NASA HQ LB3 946 (1)
Rev. 3/4/83

SPACE STATION PLANNING SCHEDULE



Legend:
ATP= Authority to proceed
IOC =Initial operational capability
PDR= Preliminary design review
SRR= System requirements review

NASA HQ MF 83 2268(1)
6-3-83

MISSION ANALYSIS STUDIES

- EIGHT $787,500 STUDIES TO ANALYZE THE SCIENCE,APPLICATIONS, TECHNOLOGY DEVELOPMENT,NATIONAL SECURITY AND SPACE OPERATIONS MISSIONS THAT REQUIRE OR WOULD MATERIALLY BENEFIT FROM A PERMANENT SPACE STATION IN LOW EARTH ORBIT
- CONTRACTORS: BOEING, GENERAL DYNAMICS, GRUMMAN, LOCKHEED, MCDONNELL DOUGLAS, MARTIN MARIETTA, ROCKWELL, AND TRW
- EMPHASIS ON USER COMMUNITIES. ARCHITECTURE NOT CONFIGURATION
- SCHEDULE

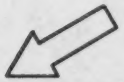
RFP RELEASED	JUNE 28, 1982
CONTRACTS SIGNED	AUGUST 20, 1982
MID-TERM BRIEFINGS	NOVEMBER 15-18, 1982
FINAL BRIEFINGS	WEEK OF APRIL 4, 1983
FINAL REPORTS	APRIL 22, 1983

- PARTICIPATION BY DOD
- SIMILAR STUDIES BY ESA, ITALY, GERMANY, JAPAN, FRANCE AND CANADA
- STUDIES WILL BE INTEGRATED BY NASA INTO SINGLE SET OF TIME-PHASED MISSION OBJECTIVES AND CORRESPONDING SPACE STATION REQUIREMENTS, FROM WHICH ARCHITECTURAL OPTIONS WILL BE DERIVED

NASA HQ L083-1738 (1)
Rev. 7-7-83

SPACE STATION DEFINITION: MISSION SYNTHESIS WORKSHOP

- MAY 6-13, 1983
- LANGLEY RESEARCH CENTER, VA
- 42 PARTICIPANTS
  - INDUSTRY
  - USAF OBSERVERS
  - NASA



TIME PHASED MISSION SET

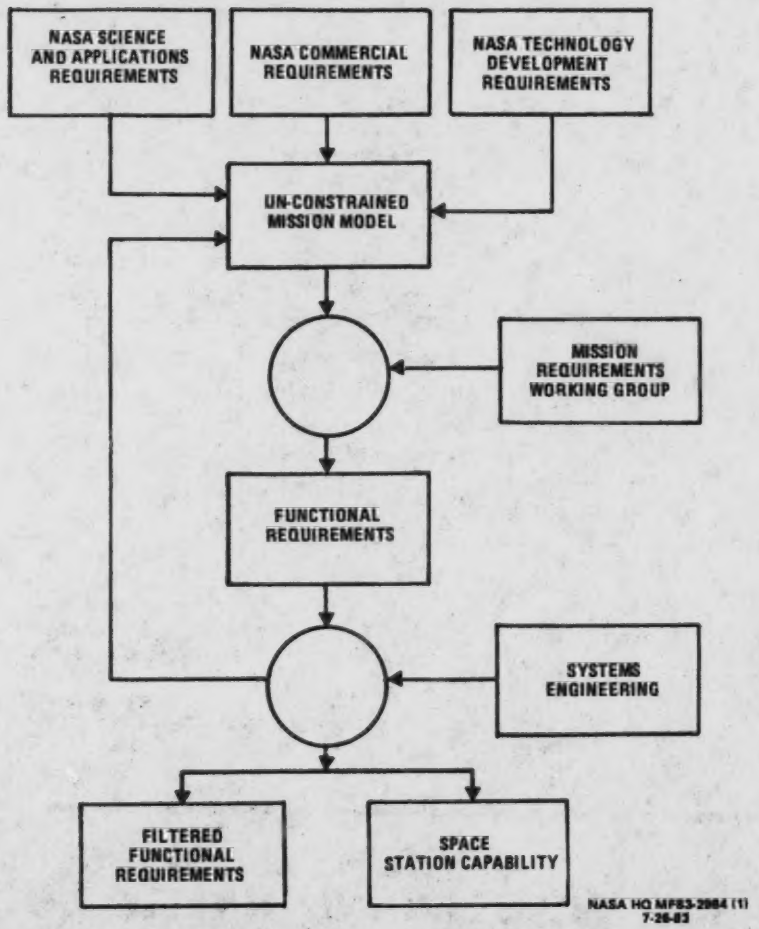
- 107 MISSIONS (1991-2000)
- REALISTIC
- IN FIELDS OF:
  - SCIENCE AND APPLICATIONS
  - COMMERCIAL
  - TECHNOLOGY DEVELOPMENT
- COMPUTERIZED DATA BASE FOR EACH MISSION
- REDUCED MISSION SET
- "MINIMUM ACCEPTABLE" MISSION SET

BASELINE REQUIREMENTS

- FOR STATION AT 28.5°
- USER POWER: 55 KW
- USER PRESSURIZED VOLUME: 120 M^3
- DATA: 100 MBPS
- CREW: 6 (5 FOR PAYLOAD OPS.)
- TMS SERVICING
- MOUNTS: 4-6
- PLUS POLAR PLATFORM:
  - 12.5 KW
  - 4 MOUNTS
  - 300 MBPS

NASA HQ MF83-2239 (1)
Rev. 7-25-83

MISSION SYNTHESIS ACTIVITY



SPACE STATION DEFINITION
PRELIMINARY MISSION DATA BASE (1991 - 2000)

SCIENCE AND APPLICATIONS

Astrophysics	22
Earth Science and Applications	5
Solar System Exploration	10
Life Sciences	6
Materials Science	4
Communications	1
	(48)

COMMERCIAL

Materials Processing in Space	11
Earth and Oceans Observations	3
Communications	14
	(28)

TECHNOLOGY DEVELOPMENT

Materials and Structures	5
Energy Conversion	3
Computer Science and Electronics	4
Propulsion	2
Controls and Human Factors	5
Space Station Systems/Operations	8
Fluid and Thermal Physics	4
	(31)

TOTAL 107

NASA HQ MFBS-1877 (1)
Rev. 8-24-83

SPACE STATION DEFINITION
REQUIREMENTS DATA SUPPLIED TO CONCEPT DEVELOPMENT GROUP

- MISSION SCHEDULES
- MISSION DATA SHEETS
- SPACE STATION FUNCTIONAL REQUIREMENTS:

	1991-1992	1993-1995	1996-1998	1999-2000
Crew Hours/Year				
Av. Power/KW				
Payload Mounts				
Servicing/Man Hrs				
Transportation/No. Flights by Mass Cat.				
Volume/M^3				
Data/MBPS				
Mass/KG				

NASA HQ MF83-1978 (1)
5-11-83

27-393 O - 83 - 5

SPACE STATION DEFINITION
BASIS FOR SPACE SCIENCE AND APPLICATIONS
PRELIMINARY MISSION MODEL

- Long range plan of NASA's Office of Space Science and Applications
- Space Applications Board Summer Study
- Space Platform Payload Requirements and Accommodation studies
- Mission Analysis Contractor Studies

- Field Committee Report (astrophysics)
- SSEC Core Program (solar system exploration)
- OPEN and TOPEX studies (earth sciences)
- Fabricant report, users workshop (life sciences)
- USRA and TRW workshops (materials processing in space)
- Commercial opportunities report (communications)
- Workshops

NASA HQ MF83-1980 (1)
5-11-83

SPACE STATION DEFINITION
SPACE SCIENCE AND APPLICATIONS POTENTIAL UTILITY OF A SPACE STATION

ON-BOARD ACCOMMODATION

- Life sciences
- Intensive man-interactive investigations (e.g., mps)
- Other (e.g., Cosmic Ray)

PLATFORMS

- Contamination
- Orbit requirements

SERVICING AND CONSTRUCTION

- Free flying craft already launched
- Co-orbiting platform(s), from station
- Other platforms, from orbiter if not station

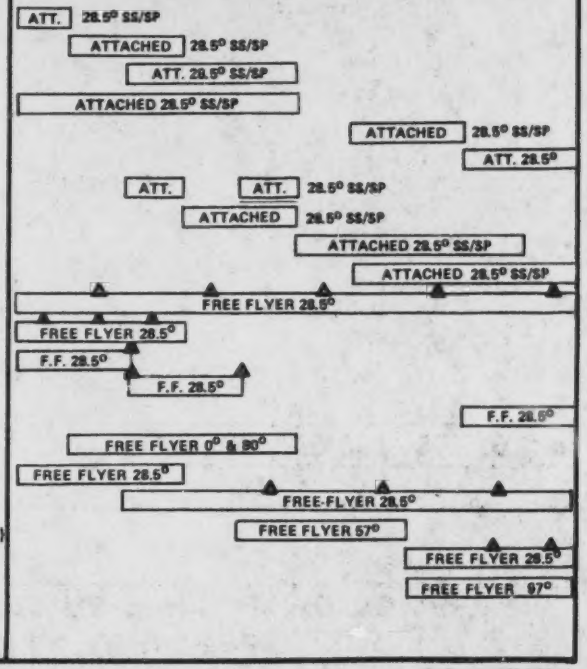
TRANSPORTATION NODE

- Geosynch satellites
- Solar system missions

NASA HQ MF83-1979 (1)
5-11-83

SPACE STATION DEFINITION
ASTROPHYSICS
FIRST CUT AT UNCONSTRAINED TIME-PHASED MISSION SET

MISSIONS		YEAR									
CODE	NAME	91	92	93	94	95	96	97	98	99	00
SAA 0001	SPECTRA OF COSMIC RAY NUCLEI (SCRN)										
SAA 0002	SPACE PLASMA PHYSICS										
SAA 0006	STARLAB										
SAA 0003	SOLAR OPTICAL TELESCOPE (SOT)										
SAA 0009	PINHOLE/OCCULTER FACILITY										
SAA 0011	ADVANCED SOLAR OBSERVATORY (ASO)										
SAA 0004	SHUTTLE IR TELESCOPE FAC. (SIRTF)										
SAA 0005	TRANSITION RADIATION & ION CAL. (TRIC)										
SAA 0007	HIGH THROUGHPUT MISSION (HTM)										
SAA 0008	HIGH ENERGY ISOTOPE										
SAA 0012	SPACE TELESCOPE (ST)										
SAA 0013	GAMMA RAY OBSERVATORY (GRO)										
SAA 0014	X-RAY TIMING (XTE)										
SAA 0019	FAR UV SPECTROSCOPY EXP. (FUSE)										
SAA 0010	SOLAR CORONA DIAGNOSTIC EXP.										
SAA 0015	OPEN										
SAA 0016	SOLAR MAX MISSION										
SAA 0017	ADV. X-RAY ASTROPHYSICS FAC. (AXAF)										
SAA 0018	VERY LONG BASELINE INTERFEROMETER (VLBI)										
SAA 0020	LARGE DEPLOYABLE REFLECTOR (LDR)										
SAA 0021	SIRTF SUNSYNCH										
SAA 0022	SOLAR DYNAMICS OBSERVATORY										



NASA HQ MF83-2100 (1)
5-24-83

SPACE STATION DEFINITION
SOLAR SYSTEM EXPLORATION:
FIRST CUT AT UNCONSTRAINED TIME-PHASED MISSION SET

MISSIONS		YEAR									
CODE	NAME	91	92	93	94	95	96	97	98	99	00
SAA 0101	MARS GEOCHEM/ CLIMATOLOGY ORBITER	▲									
SAA 0102	LUNAR GEOCHEM ORBITER	▲									
SAA 0103	COMET RENDEZVOUS	▲									
SAA 0104	VENUS ATMOSPHERE PROBE				▲						
SAA 0105	TITAN PROBE			▲							
SAA 0106	SATURN PROBE				▲						
SAA 0107	MAIN BELT ASTEROID RENDEZVOUS							▲			
SAA 0108	SATURN ORBITER								▲		
SAA 0109	NEAR EARTH ASTEROID RENDEZVOUS							▲			
SAA 0110	MARS SAMPLE RETURN									△	

NASA HQ MFS3-1981 (1)
REV. 5-24-83

SPACE STATION: FIRST CUT AT CAPABILITIES

	INITIAL	FUTURE
BASE AT 28.5°		
Crew	6 – 8	12 – 18
Power	60KW	160KW
Attached payloads	Some	More
R&D pressurized modules	2 – 3 (120M^3)	4 – 6 (300M^3)
Satellite servicing capability	Initial (close by)	Mature
Smart front-end TMS	Available	Available
Data system	300 MBPS	300 MBPS
PLATFORMS		
28.5°/15KW	One	Several
Polar/15KW	One	One
SPACE-BASED OTV	No	Yes
MANNED POLAR STATION	No	?

NASA HQ MF83-2422 (1)
6-16-83

SPACE STATION DEFINITION
CONCEPT DEVELOPMENT STUDY TOPICS

- Human Factors/Crew Size
- ECLS
- Standard Hardware
- Open Hatch Philosophy
- Thermal Systems
- Power Systems
- Controlability
- Safe Haven
- Multi-Berthing Adaptor Size
- Contamination Control
- Pointing Accomodations
- User Data Capability
- Logistics Resupply
- TMS/OTV Servicing

NASA HQ MF83-2834 (1)
7-19-83

TWO SMALL SPACE STATION STUDY ACTIVITIES

COMMERCIAL USER DEVELOPMENT

- NASA sponsoring two small, nine-month studies by Booz Allen and Coopers Lybrand
- studies will
  - develop further the commercial user contacts made during the space station mission analysis contracts
  - develop time-phased commercial space station mission scenarios, including requirements
  - assess feasibility of utilizing commercial firm(s) as intermediary between U.S. government and private sector in developing commercial utilization of the station
- studies to begin in May, 1983

INNOVATIVE UTILIZATION OF A SPACE STATION

- on November 1, 1982, NASA requested proposals from science and applications communities on space station utilization
- goal was to broaden NASA's base of ideas and to involve individuals not part of NASA's traditional advisory and industrial channels
- over 300 proposals received, 18 accepted (total of $400K available)
- selected proposals include life sciences, astrophysics, environmental sciences, materials processing, and technology development
- final reports: September, 1983

NASA HQ L083-1113 (1)
Rev. 4-25-83

SPACE STATION PLANNING: "THE SIG"

- Senior Interagency Group (Space) Chartered to Provide
  - forum for discussion of space-related issues
  - advice on proposed changes to national space policy
  - referral of space-related issues to President, as necessary
- Membership of the SIG (Space)
  - State, Defense, Commerce
  - NASA, DCI, CJCS, ACDA
  - observers: OMB, OSTP
  - chaired by Assistant to President for National Security Affairs
- SIG Has a Number of Working Groups: Remote Sensing, Launch Policies, Commercialization, Technology, Organization/Funding, Planetary Exploration, and Space Station
- SIG (Space) Space Station Working Group
  - report to SIG by November, 83 on policy issues for an Administration decision on whether or not to proceed with a permanently based, manned space station
  - chaired by NASA (John Hodge)
  - first meeting: October 21, 1982
  - summary paper submitted July 1, 1983
  - summary paper covers questions of maintaining leadership, national security and foreign policy implications, economic/social impacts, and how space station or alternative satisfies national/international requirements

NASA HQ LG83-495 (1)
Rev. 7-13-83

OPTIONS

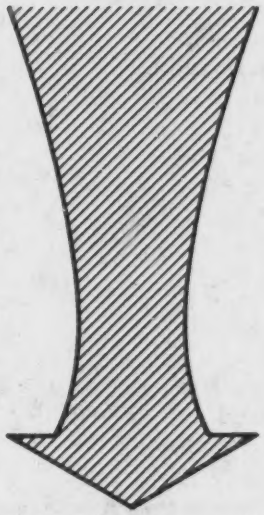
SPACE STATION TECHNOLOGY STEERING COMMITTEE

WORKING GROUPS	TECHNOLOGY THEMES	OBJECTIVES
DATA MANAGEMENT	HUMAN CAPABILITIES IN SPACE	ESTABLISH DESIRED LEVEL OF TECHNOLOGY FOR INITIAL SPACE STATION DESIGN
ENVIRONMENTAL CONTROL AND LIFE SUPPORT	SYSTEM AND SUBSYSTEM AUTOMATION	ESTABLISH LONGER-TERM TECHNOLOGY FOR LATER APPLICATION
SYSTEMS/OPERATIONS TECHNOLOGY	ADVANCED INFORMATION SYSTEM	ASSESS NASA's TECHNOLOGY BASE FOR SUITABILITY TO SPACE STATION
ATTITUDE, CONTROL, AND STABILIZATION	ENERGY MANAGEMENT	PLAN A TECHNOLOGY PROGRAM TO MOVE TECHNOLOGY FROM CURRENT STATUS TO DESIRED LEVEL
POWER	EVOLUTIONARY ATTITUDE CONTROL, AND STABILIZATION	PLAN FOR USE OF STATION AS AN R&T FACILITY
THERMAL	HYDROGEN-OXYGEN FLUID SYSTEMS	
AUXILIARY PROPULSION	SPACE OPERATIONS TECHNOLOGY	
STRUCTURES AND MECHANISMS		
COMMUNICATIONS		
HUMAN CAPABILITIES		

NASA RA HQ LCC3-497 (1)
12-10-82

TECHNOLOGY ISSUES

Technology optimized design



In-space operations

Long life systems

Human productivity

Evolution

Utility

Autonomy

Maintainability

Automation

Technology transparency

User transparency

Low life cycle costs

NASA HQ MF 83 2270(1)
6-3-83

TECHNOLOGY CHALLENGES

Advanced end to end information systems	fault tolerant software user friendly systems distributed architecture
High capacity electrical power generation	concentrated GaAs arrays regenerative fuel cells nuclear systems
Cryogenic fluid management	propellant transfer long term propellant storage integrated H/O economy
Thermal management	high capacity heat pipe radiators integrated thermal bus thermal coatings
Crew systems and life support	water loop closure CO_2 loop closure extended EVA
Human capabilities	end effectors quick response EVA telepresence

NASA HQ MF ID 225611
6 3 ID

SPACE STATION PLANNING: ADVANCED DEVELOPMENT ACTIVITIES

OBJECTIVES

- develop "test bed" capabilities along major subsystem disciplines to evaluate technology and estimate risk
- provide the "transfer function" for new technology into the space station development program
- provide technology options to program manager
- establish a qualified subcontractor cadre for system implementation

APPROACH

- manage advanced development program at NASA centers
  - implement "test bed" capabilities
  - select technologies for brassboard/prototype fabrication and demonstration
  - coordinate advanced development activities with technologist
  - establish test criteria and procedures
- coordinate closely with OAST technology program
  - provide developer focus to early technology activities
  - ensure compatability in program content and schedule

NASA HQ L083-176 (1)
Rev. 5-19-83

ADVANCED DEVELOPMENT—INITIAL TECHNOLOGY TEST-BED ACTIVITIES

- OPERATING AND DATA MANAGEMENT SYSTEM
  - DISTRIBUTIVE ARCHITECTURE, FAULT TOLERANT SOFTWARE, AUTONOMY
- ENVIRONMENTAL CONTROL/LIFE SUPPORT
  - REGENERATIVE LIFE SUPPORT
- ELECTRIC POWER SYSTEM
  - GENERATION, STORAGE, DISTRIBUTION
- ON-ORBIT CONTROL SYSTEMS
  - ATTITUDE CONTROL AND ON-BOARD PROPULSION
- THERMAL CONTROL SYSTEM
- SPACE OPERATION MECHANISMS
  - ACTUATORS & DRIVES, DOCKING, BERTHING

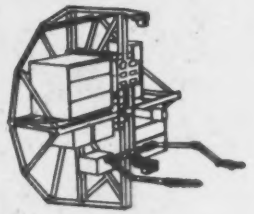
NASA HQ LG83 1083 (1)
3 4 83

HUMAN PRODUCTIVITY IN SPACE

Functional drivers

- Observations, experiments, and evaluations
- Spacecraft servicing and repair
- Assembly and construction
- Orbital launch operations

Telepresence



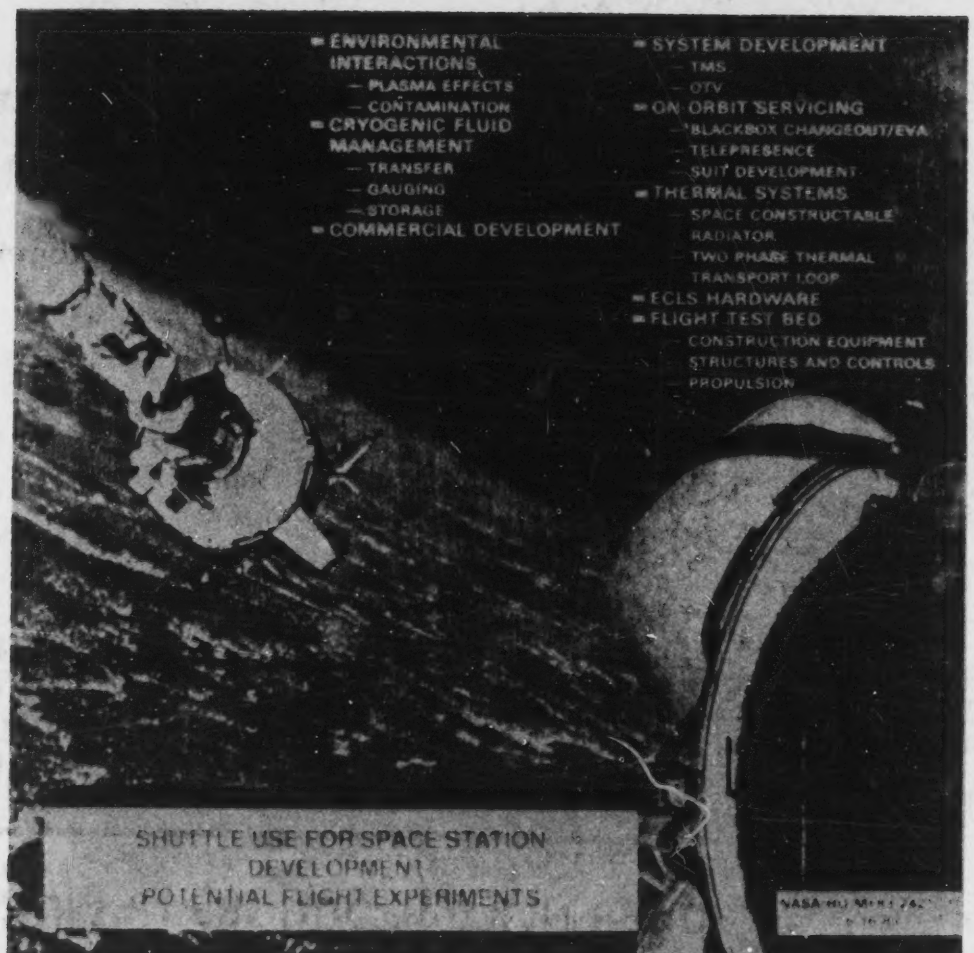
EVA work aids

Crew station

Technology thrusts

- Crew systems
  - Crew station (IVA)
  - EVA preassure suit
  - EVA work station
  - Teloperation/Robotics
- Dexterity and mobility
  - Tools/mechanisms
  - Assembly aids
  - Local transportation
- Medical support
- Habitability

NASA HQ MF 83 2245(1)
5-3-83


• ENVIRONMENTAL INTERACTIONS
— PLASMA EFFECTS
— CONTAMINATION
• CRYOGENIC FLUID MANAGEMENT
— TRANSFER
— GAUGING
— STORAGE
• COMMERCIAL DEVELOPMENT
• SYSTEM DEVELOPMENT
— TMS
— OTV
• ON ORBIT SERVICING
— BLACKBOX CHANGEOUT/EVA
— TELEPRESENCE
— SUIT DEVELOPMENT
• THERMAL SYSTEMS
— SPACE CONSTRUCTABLE RADIATOR
— TWO PHASE THERMAL TRANSPORT LOOP
• ECLS HARDWARE
• FLIGHT TEST BED
— CONSTRUCTION EQUIPMENT
— STRUCTURES AND CONTROLS
— PROPULSION
SHUTTLE USE FOR SPACE STATION DEVELOPMENT POTENTIAL FLIGHT EXPERIMENTS

27-393 O - 83 - 6

SPACE STATION PLANNING: APPROACH TO DEFINITION

NOW	LATER	SO THAT	LEADING TO
• NASA centers on board • Technology Steering Committee at work • User communities involved • First cut of time phased mission sets prepared • Preliminary systems definition and concept development begun • Management approach under consideration	• Concept defined • Mission requirements well understood • Detailed system design carried to subsystem level • Project, development and fabrication, test and operations plans completed • Management plan in place • Industry team selected via competition	○ Systems are well understood ○ Technology is reliable ○ Cost and schedule estimates are real	• Informed decision on the nature of the development program

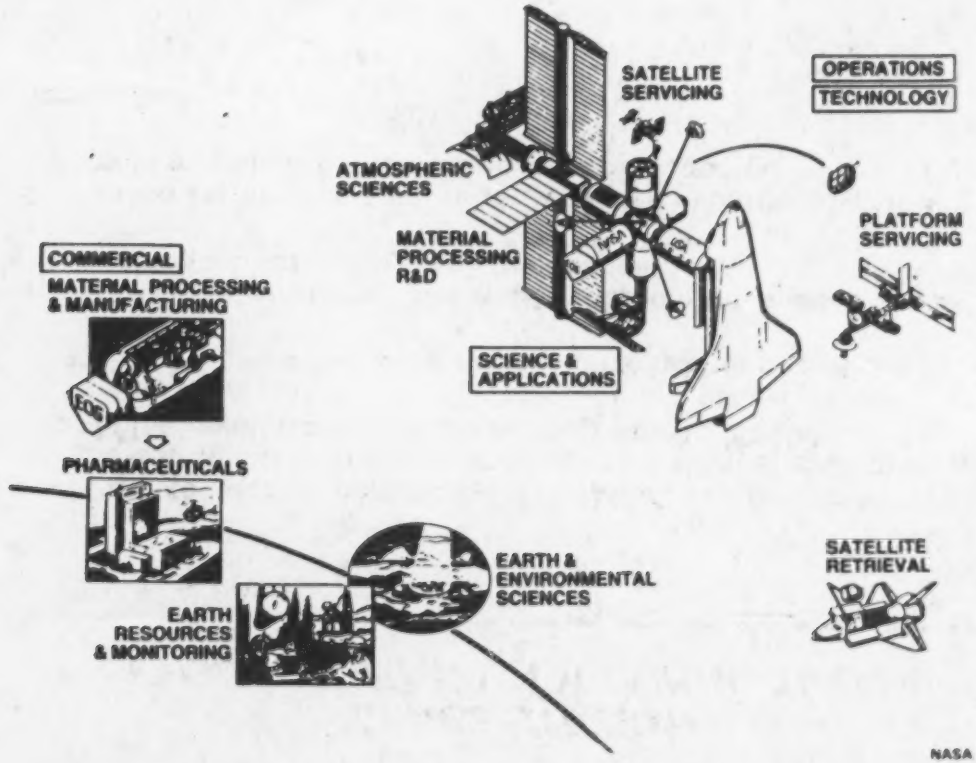
NASA HQ LG83-494 (1)
Rev. 7-25-83

LONG RANGE OBJECTIVES

- Establish the means for permanent presence of people in space
- Enable routine, continuous utilization of space for science, applications, technology development, commercial exploitation, national security, and operations
- Develop and exploit the synergistic effects of the man/machine combination in space
- Provide essential system elements and operational practices for an integrated national space capability
- Reduce the cost and complexity of living in and using space

NASA HQ MF 83-2259(1)
6-3-83

SPACE STATION
INITIAL



NASA HQ MF 83 2271
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SPACE STATION
EVOLUTION: AN UNDERLYING THEME

- Prior to development of the STS NASA had tended to pursue manned program goals using dedicated systems with limited evolutionary capability (e.g. Apollo, Skylab)
- Planning must look beyond low-earth orbital operations
- Permanent presence goal must embrace principles of utility, maintainability and capability enhancement
- Space station architecture must enable evolutionary growth, by incremental additions and/or modifications

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RESPONSES TO WRITTEN QUESTIONS SUBMITTED BY CHAIRMAN VOLKMER DURING THE HEARING BEFORE THE HOUSE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS ON AUGUST 2, 1983, TO MR. HODGE

QUESTION MFA-1:

Mr. Hodge, having reviewed all the past work on Space Station requirements and studies:

a. Are the arguments for a permanent manned presence in space as valid today as they supposedly were in the late 1960's?

b. Have we learned some things in the 1970's and early 1980's that add to the need for a station?

c. In the early 1970's you had two phase B studies on concepts--what was the estimated cost of a modular concept with 6-12 people?

ANSWER MFA-1:

a. and b. Yes, NASA believes so. But the arguments for permanent manned presence in space are also different today than they were in the late 1960's. In the earlier days, the principal concept of the space station was that of an orbital laboratory whereon many experiments were aggregated and the synergism of size, facilities and manned interaction expected the whole to be greater than the sum of the parts.

Today, this is still true. However, the onboard experiments or laboratory functions are only about a quarter of the total postulated capabilities. Since 1970, many other functions have been studied and NASA now believes there is more far-reaching value for a space station based upon operational and utilitarian functions. These now include:

- tending of freeflying satellites to bring the economics of reusability to spacecraft as well as launch vehicles;
- addition of extensive commercial missions;
- use of a permanent space base for assembly of large structures; and
- use of the permanent base for launch, retrieval and reuse of upper stages.

In essence, NASA's current space station planning is based on the concept of accumulating assets in space and utilizing them in a continuous manner for science, applications, transportation, technology development and commercial missions.

c. The estimated development cost of such a concept in FY 1984 dollars, including comparable support cost to those included in our current estimate, is approximately $8.5 billion. It should

be noted, however, that the capabilities and functions of the earlier concept are not equivalent to those included in the current concept.

QUESTION MFA-2:

In President Reagan's July 4, 1982, statement on National Space Policy that you refer to in your briefing--when he talked about "we must look aggressively to the future by demonstrating the potential of the Shuttle", do you consider an extended on-orbit stay-time Space Shuttle of up to 30 days--

a. A threat to a go-ahead on station?

b. A complementary activity preceding station?

c. An experimental platform to test ideas and experiments for a more permanent station?

d. Do you see a dedicated Shuttle vehicle for this purpose?

ANSWER MFA-2:

a. NASA does not see it as a threat to a go-ahead on a space station. The currently postulated functions and capabilities for a permanent space station are predicated on continuous space-based operations as opposed to the current ground-based way of doing business.

b. The Shuttle is viewed by NASA as complementary to a permanent space station, as it will provide the primary transportation and logistics resupply to and from the station. Current planning includes flight experiments on board the Shuttle to demonstrate technology developments for a space station. While an extended duration orbiter could potentially demonstrate some of the capabilities of a permanent space station, NASA has no current plans to incorporate an extended duration orbiter in a space station program.

c. The present Shuttle orbiter capabilities and stay-times are sufficient to perform those flight experiments and on-orbit activities currently planned in support of space station definition and development.

d. In view of the modifications necessary to achieve orbiter stay-times up to 30 days, it is likely that at least one dedicated Shuttle vehicle would be required for this purpose. Assurance of an operational capability over a multi-year period would probably necessitate having two orbiters appropriately outfitted.

QUESTION MFA-3:

Can you foresee a scenario where you have a commercial space station, if Congress decides against this course of action by NASA?

a. Have you received proposals to this effect?

b. Has there been any estimate of dollar costs for such a commercial venture?

c. What would you see as NASA's role, if NASA did not have its own station?

ANSWER MFA-3:

Current experience indicates that in areas such as pharmaceutical production the potential exists for viable commercial opportunities in space.

a. NASA has received no proposals to this effect. However, NASA is aware of at least one company investigating the potential for private construction of a space station.

b. NASA has no information on cost estimates for such a commercial venture.

c. NASA's role in space would be to continue to reduce cost and increase operational efficiency of the shuttle; to pursue science and exploration in space through unmanned vehicles and instruments; to advance civil communications, remote sensing and data processing technologies; and, to extend space capabilities through automation as far as possible through existing capabilities.

QUESTION MFA-4:

Mr. Hodge, do you consider the station activity as part of another "space race" with the Soviet Union? I notice you mentioned "meeting Soviet challenges" in your space station chart.

ANSWER MFA-4:

I believe the Soviet Union is attempting to become what the United States is at present: the preeminent power in space. I believe also that a space station would assure, for the U.S., civil leadership in space during the 1990's. We are not in a "race" with the Soviet Union. We are in a competitive arena where the stakes are enormous.

QUESTION MFA-5:

In your chart dealing with Fiscal Year 1984 END-ITEMS, you mention DOD participation plan--in the 1960's and early 1970's, DOD made it clear that they had no real requirement for a Space Station use--

a. Has the DOD position changed?

b. Is DOD in a position to support NASA with resources?

c. What is the level of involvement planned by DOD during this cycle, the development cycle and the operations cycle?

ANSWER MFA-5:

a. At present, DOD has no identified requirements for a permanent manned space station.

b. DOD contributed a small portion of the funds required for the mission requirements studies and has provided an Air Force officer as a full-time representative on the Space Station Task Force. However, no DOD resources are projected to support NASA's space station activities at this time.

c. Any such level of involvement would be determined by DOD rather than NASA. However, NASA will continue to keep the Department fully informed of our space station activities.

QUESTION MFA-6:

In your Space Station Planning Guidelines Chart--You mention the cost of initial capability of $7.5 - $9 billion.

a. What do those figures include?

b. What about operations?

c. Earlier efforts on stations appeared to indicate approximately $2-3 billion for development?

d. Since the TMS and the OTV can be used by Shuttle as well as space station, why are you putting these two items in the space station budget? Shouldn't these vehicles stand alone?

e. What year dollars is the $7.5 - 9 billion figure you mention, 1985?

f. How many platforms are considered in that figure? Can't you have these platforms without stations? Can they be commercialized?

ANSWER MFA-6:

a. These NASA planning estimates include the costs of developing the elements of a space station with an initial operating capability in 1991.

b. Operations costs would occur subsequent to the above development effort and are not included in the estimates.

c. The $2-3 billion NASA estimates were for a station with a more limited capability and were stated in earlier year dollars, thereby including less provision for inflation than our current estimates which are in FY 1984 dollars.

d. The basic development costs of the TMS and OTV are not contained in the space station estimates. What we have included in our figures is the cost of developing the necessary additional capabilities for a TMS based on a space station and a servicing capability for a space-based OTV.

e. The planning estimate is in FY 1984 year dollars.

f. Two platforms are included: one at 28.5° and one in polar orbit. Yes, some types of platforms could be placed at those inclinations but they might be considerably different and less capable than ones associated with a space station program. While current agency planning for platform utilization is primarily oriented to science missions, such as astrophysics on the 28.5° platform, commercial payloads have not been excluded and such platforms could ultimately be commericalized.

QUESTION MFA-7:

Referring to the Mission Analysis Studies Chart--

a. How would you characterize the industry position (by the eight companies) on stations?

b. Do they agree on the $7.5 - 9 billion figure?

c. Did all the study contractors have the same set of study criteria?

d. How much participation was there by DOD?

e. Is DOD looking at a reimbursable plan for this use of stations where appropriate?

f. How close to your criteria for our contractors was the international community studies?

g. What kind of competition by industry do you foresee for FY 1985?

h. Do you anticipate any teaming arrangements for phase B? Whether they be domestic or international?

i. How would you define the difference between international participation and international cooperation?

ANSWER MFA-7:

a. Results of the eight NASA-funded industry studies were that a space station could: contribute to space science and applications; play a key role in the development of space commercial opportunities; serve an important cost effective role as a space transportation node; enable the construction and assembly of large space structures; provide unique research and technology development facilities in a weightless

environment; establish a source of service capabilities for itself and unmanned assets in orbit; and, provide the facility for the development of knowledge in life sciences to enable future space options such as lunar colonization or interplanetary travel. Man's presence could be beneficial and a space station development could be cost effective, given certain assumptions.

b. At the completion of the eight industry studies, it was their consensus that a space station of limited capability could be constructed for approximately $6 billion. This was based on an extremely limited study of space station architecture and no study on specific space station configurations. Further studies of space station architecture by NASA with participation by the eight contractors have resulted in the refined planning estimate of $7.5 to $9 billion for a space station that would maintain NASA's leadership in space.

c. All the study contractors had the same set of study criteria.

d. DOD, although not having any identified unique requirements for a space station, has had one Air Force Space Command officer assigned to NASA since February, 1983, as a liaison working directly with the Space Station Task Force. He is a member of the NASA's Mission Requirements Working Group and participated in the Mission Analysis Synthesis Working Group for two weeks in May, 1983. In addition, other military officers were present during the synthesis at the Langley Research Center.

e. No DOD plan for reimbursable use of a space station is currently in work.

f. Studies performed by the international community used essentially the same criteria as the eight domestic contractor studies with the exception of deriving potential mission requirements for national security purposes.

g. Assuming that definition funding is approved for space station in FY 1985, NASA anticipates industry competition for the preliminary design phase in FY 1985 and FY 1986. We have noted an increasing interest by a range of industrial companies who could potentially play a role in space station development and construction.

h. It is too early to anticipate potential teaming of contractors. This will depend upon the availability and amounts of funding as well as the acquisition approach selected.

i. International participation in a space station program is defined as the provision of a space station component by a

foreign entity in exchange for some yet to be determined quid pro quo. International cooperation is a broader term and could, for example, include either participation or joint utilization of space station capabilities, or both.

QUESTION MFA-8:

In FY 1984, what are NASA's plans to keep potential users involved in space station activities?

ANSWER MFA-8:

In FY 1984, NASA will develop a detailed space station user accommodation plan for potential users in the 1990's. NASA has assigned specific focal personnel for the user areas of science and applications, commercial, applications technology development and national security requirements to work specifically with members of these communities. Time-phased space station use profiles will be developed jointly with the users and integrated so that users may be accommodated with respect to both functional and operational capabilities. Non-aerospace users will be involved as space station capabilities unfold and evaluation methods are developed to determine the degree to which user needs can be met. Various mechanisms will be used including continued interaction with the Space Science Board and Space Applications Board, joint endeavor agreements, commercialization study contracts and individual contacts with representatives of the user community.

QUESTION MFA-9:

Apart from materials processing and life sciences, there appears to be little support for a space station from scientists. Would you like to comment on this, and tell us how this lack of definitive support is influencing your deliberations?

ANSWER MFA-9:

There is support within the scientific community for a space station. Their concern is that a national commitment to a space station might not result in the availability of sufficient resources for the scientific community to take effective advantage of the space station. In a letter to the Administrator from the Space Science Board, this concern was enunciated. In effect, the letter states that user community budgets must increase if the full potential of a space station is to be realized. In a more recent letter the Board stated "The Board sees no scientific need for the space station during the next 20 years."

In addition to the life sciences and materials sciences, there is support for a space station from segments of the astrophysics community. Also, a space station supporting several observatories may result in the prospect of conducting astrophysics observations in a more cost-effective manner.

The Space Applications Board, in their summer study conducted last year, recommended strongly the development of an unmanned polar platform that would incorporate multi-spectral instruments that could be coherently processed for intensive observation of the atmosphere, the oceans and the solid land mass. This concept could require periodic manned intervention and interaction. Such a platform is currently included in the initial space station capability.

The Solar System Exploration Committee, at a recent meeting in Aspen, Colorado, addressed the issue of the potential of a space station as a transportation node to effect the kind of expansive planetary exploration endeavors that have not been considered since the completion of the Viking program.

In summary, the scientific community understands the potential value of a space station, but their support is contingent upon additional resources being available to the scientific community to use effectively this important new asset if and when it becomes available.

QUESTION MFA-10:

Do you see the need for considerable advancement in automation and development of robotics in order to establish a useful space station?

ANSWER MFA-10:

The development of a manned space station would naturally involve advancement of automated systems and the development of robotics. Indeed, these endeavors are synergistic and complementary. A major space station development issue is the definition of the optimum partition of functions between humans and automated systems. In a recent issue of Astronautics and Aeronautics, Dr. Frosch, the Vice President of General Motors Research Laboratories, and former NASA Administrator, addressed this issue. The training of robots demands human intervention to guide the robot through the sequence of operations and highlight the appropriate sensory queues. The robot is then programmed to accept this information as a programmed instruction series. For functions that can be completely defined in detail, this programming by a human operator can be accomplished remotely (from the Earth). However, for functions that are not fully defined, the operational sequence must be developed in an adaptive manner. In this mode, a closer coupling between man and machine is mandatory. This close coupling requirement is more compelling if the time constant of the function to be performed is short (i.e., a time delay cannot be tolerated).

In summary, the most effective use of a space station will occur when the operational scenarios consider the most effective complementary utilization of men, robotics and automated systems.

QUESTION MFA-11:

For a space station to be "user friendly", what types of service would it have to provide?

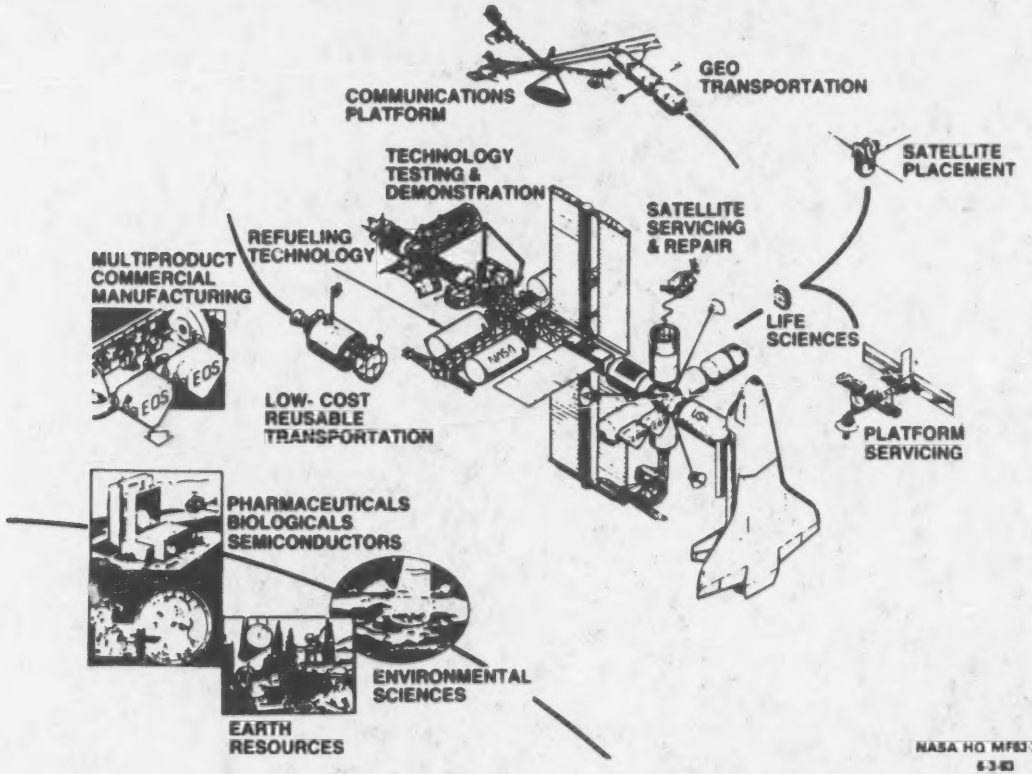
ANSWER MFA-11:

Any future space station must have clearly defined and simple procedures for the introduction of new users. Adequate provision must be made for training of payload specialists and ground support personnel. Adequate facilities must be available for users to interface with and analyze data from the onboard sources. The following types of space station services are currently envisioned:

- computation,
- personnel,
- construction and assembly,
- maintenance and operations,
- logistics,
- transportation,
- research and development, and
- platform/freeflyers.

Also, there must be continuous dialogue and feedback between the staff of experts in space station systems and space station users.

SPACE STATION
FUTURE



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Strategy for Space
Permanent Utilization
Routine Space Access
Space Operations Feasibility
Exploration
Pioneering
SPACE STATION
SHUTTLE
SKYLAB
APOLLO
GEMINI
MERCURY

Mr. VOLKMER. Thank you very much, Mr. Hodge.

We will proceed with the testimony from Mr. Kenneth Pedersen, Director of International Affairs Division. And upon completion of that, we will go to questions.

Mr. PEDERSEN. Thank you, Mr. Chairman.

Let me begin by indicating a little about what we have been doing and have not been attempting to do with respect to international participation in the space station work we've done so far.

John Hodge mentioned in his presentation that we place a very high value on keeping the user community involved in this space station effort. And, so far, our interaction with our international colleagues has focused almost exclusively on their role as potential users of the space station. I think that's extremely important. What we have talked with them about to this stage and worked with them is in terms of how their space programs, their user communities in their countries, might benefit by a space station in terms of providing capabilities to their programs.

The other side of this coin is to say what we have not been actively talking to them about to date, and that is contribution of hardware or some way involved in the design and development of a space station. That option remains open. We have not attempted to foreclose it. And I think it's an option we ought to consider very carefully. But it has not been the focus of our discussions with the international community to date.

May I have the first slide?

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Mr. PEDERSEN. With respect to the activities and discussions that have gone so far, we have operated under a set of, I think, informally understood groundrules (figure 1). I don't know that these groundrules have ever been before put on paper, but they've certainly been discussed in our discussions with our international colleagues.

First, a point that we have made so many times that I'm sure some of our international friends are tired of hearing it is that we have no approved program, that this is not an approved program. Yet, the President has not made an executive branch commitment, the Congress has not been seized with the question yet of whether this should be something that should be funded and gone ahead with. This is an important point in terms of our international dealings, because what it means is that we are not in a position, and ought not to be in a position to sign formal agreements or begin negotiating formal understandings. Obviously, on the part of some of our international colleagues, they would like to begin moving toward a clear understanding of what we propose to do, what kind of commitments we're proposing to make, what kind of contributions we might be interested in receiving from them.

Our response has been we cannot and ought not to begin that process now. We are talking now about user requirements; we are talking now about how a space station might contribute to their program; and not at this point about how they might contribute directly to a space station. We also have made clear to them that, in terms of their efforts, their parallel studies that they have been undertaking to study their requirements, that this must be done with their own funding, that NASA is not prepared, both from a budget-

ary perspective and, I think, in terms of good policy to fund studies abroad. And, indeed, they have responded by undertaking a number of studies, and these have been funded by their own processes domestically.

I indicated no formal agreements at this time. We've indicated we are not in a position to do that. We would have no basis to make any formal agreements; and, similarly, no commitments at this time. We are not in a position to make any commitments, not only because we have no legislative or budgetary authority for proceeding with a program as such, but also we haven't even reached the point of designing a space station. We wouldn't know what kinds of commitments to make with respect to what part of a space station, even were we so inclined, because we have assiduously—John Hodge, Bob Freitag and their colleagues—stayed away from attempting to indicate that we know what a space station would look like and what all the pieces would look like.

I must say John Hodge only recently allowed some of his people to begin drawing some pictures. Up until recently, there was even a ban on drawing pictures. All doodles were destroyed at the end of the day to make sure that nothing got out that might be suggested as the NASA-approved design for a space station.

We have indicated to them that we are prepared to exchange the results of the studies that we undertake and the studies that they undertake with respect to mission requirements. And this has been, to the extent that we have proceeded, done. We have had several meetings with representatives from the various countries that have been involved, at which time we have briefed them on our mission requirement studies, some of the things that John mentioned. And they, in turn, have shared with us the results of their mission requirement studies to date. And we have indicated to them that we would continue to propose to hold regular meetings to exchange this information to keep them informed of what we are doing. But of equal and perhaps greater importance in terms of where we stand right now, so that we can keep informed about what their evolving and emerging requirements might be.

Could I have the next slide, please?

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Mr. PEDERSEN. I think, in a nutshell, I could summarize the current situation by saying that there appears to exist substantial foreign interest in our planning effort (figure 2). This might be—someone might say that's fairly obvious, and I suspect it might be.

Anytime a country like the United States with its large space program and its history of international cooperation indicates that it's thinking about undertaking a major project like a space station, it would be rather odd if other countries weren't interested—interested, if for no other reason, in terms of their own self-interest, in a defensive posture, as well as a constructive posture. Although I would hasten to add that, to date, we have found that our relations with them have been extremely constructive. We have found that this interest is self-generated. Now this line is put on the chart because I suspect there may be some—and I would be less than honest if I didn't confess I have heard the story repeated back to me—that somehow, NASA is out involved in a large-scale international selling venture, selling a space station.

I can only tell you that that is, to the best of our ability within NASA, not the case. We have leaned over backwards to emphasize that we do not have an approved program, that the decision with respect to international cooperation has not been made yet, we are operating in a mode in which we want to keep that option open until all parties better understand the situation, the costs and the benefits involved. But there has been no effort, insofar as we have been able to control it, to incite or otherwise engender this interest. As I said before, I think the interest is self-generated, because I think it is in their interest to have an interest. I think that's been quite adequate.

Our closest allies, our traditional partners in space, are spending a fair amount of their own funds on independent space station mission analysis and planning studies. This has principally been Canada, the European Space Agency, within Europe, France, Germany and Italy have also undertaken independent analyses, national studies. I should emphasize that they are cooperating within the ESA framework in supporting those studies, but they are also looking at how a space station might relate to their own independent national program, because in Europe, as many of you may be aware, there is the ESA, European Space Agency, program to which all countries contribute and cooperate, all of the members states cooperate and contribute. And then a number of the larger countries, such as Italy, Germany, and France, have fairly sizeable national programs of their own, quite separate from ESA. So, in this case, Germany, France and Italy are looking not only at how a space station might serve their interests in terms of the European Space Agency, but also in terms of their own national programs.

I have indicated one such example there, Italy, looking at its tethered satellite system—a program that Italy is about to embark on. They are looking at how that national program might well fit into a space station concept.

These countries are also looking, as part of their studies again, at their own initiative on what contributions they might want to make if the opportunity arises. I think it would be unrealistic to suppose that these countries wouldn't want to peek over the horizon, no matter how much we tell them about not knowing where the horizon is yet, or even if there's going to be an horizon—although, as John indicated, we're operating on the assumption that there is—how they might contribute to such a space station beyond utilization.

Some of the studies that they have undertaken begin to give us preview glances of some of their thinking on that. But, again, I would emphasize we have assiduously avoided having discussions with them about this, and we have become rather good at saying that's very interesting and the time to talk about that possibility is still several months away, until we get some clear understanding of the program.

I also note that, on the line there, too, that Japan is also undertaking some—its own independent studies. They have started a rather significant effort. They have completed an initial study. We do not have a copy of that yet, although I understand it's on its way. We have been briefed on it by the Japanese representatives. I think the Japanese interest in space stations is motivated by a

number of things. One, of course, might well be that at the time the space shuttle was conceived and the international involvement in the shuttle ultimately came to take the form of spacelab and the Canada arm, that Japan at that time chose not to become involved. I think there may be some interest on their part in this case to make sure that if that option becomes available, they are in a position to make a fully-informed decision. I think that, in many ways, accounts for a good deal of the substantial interest that they have given to the effort so far.

Next one, please.

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Mr. PEDERSEN. I've tried here (figure 3) to briefly characterize the results of the mission analysis studies that our international participants have given us so far. The details of some of their contributions, I think, Mr. Hodge and Bob Freitag might be able to speak to you even better than I, since they obviously have the responsibility of evaluating the technical aspects of these contributions.

They do appear to be thorough and wide-ranging. They're quality studies. They do not have the appearance of something that's done to check a box or some sort of cosmetic activity or to keep one's sort of foot in the door. They appear to be serious efforts to look at a space station and look at how it might fit in with their potential space programs. There appears to be a strong overlap between their findings and the findings of our own studies, our own industry studies, as well as NASA studies in the areas of science and applications. And again, I would suggest that that is not terribly surprising.

The general conclusions are that many of their missions do appear to be compatible with the current space station concepts, that is the space station does appear to be suited to the undertaking of a number of missions that they've identified. They have indicated that we need to continue having a dialog to further understand their proposed missions. We feel the same way.

This is an evolving process. As we become smarter, they in turn become smarter. As they give us their reports, we understand more about their interests. And John talked about a carrousel. It's certainly something that's a back-and-forth process. Whether it's a carrousel or a recipocal engine, I'm not sure. But it certainly involves an extensive amount of dialog. Also, we need to get a better understanding from them about what their priorities are. To date, from most of them, we have fairly lengthy lists of possible missions that they might be interested in looking at in terms of a space station. But we need to have a better understanding of what priorities they attach to those missions. We have—I guess we're at the point now where you might say we have—we have shopping lists, thoughtful shopping lists, but it's clear that the shopping lists need some prioritization.

Next slide, please.

Mr. PEDERSEN. The European Space Agency has undertaken one of the more major studies (figure 4). The report is available. I have a copy here of an executive summary. They have identified a number of payload candidates. I won't try to discuss in detail each point on the chart. I think it is self-evident. They have found that

the human presence, the possibility of a manned space station, does offer certain special benefits, especially in the areas of material science and life science and technology development.

The overall conclusions of their studies is that a space station does appear at this time to be compatible with the planning of—or in the directions that Europe is thinking about going, that it is consistent with some of the investment they have already made in space, particularly in the area of space II lab, and the Eureca unmanned platform that that is currently under development, that it does offer, they think, to them in the long run increased operational commercial space potential for commercial space utilization. It is cost effective, they believe, in the sense that they do not believe that Europe alone could develop an equivalent to space station, an equivalent manned space station to do some of the things—along some of the lines that the U.S. is talking about. And also that a manned space station need not be competitive with unmanned systems available in Europe. And, I think, there one could say that they are saying that a manned space station need not be viewed as directly competitive with, say, the Eureca platform system, or even the Ariane. to the extent they will be competitive or will not be competitive, I think, obviously remains to be seen. And that's a careful balancing act of priorities that we're all going to obviously have to be concerned with.

Next slide.

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Mr. PEDERSEN. Japan, as indicated here (figure 5), has established an ad hoc committee on space station. They did that approximately a year ago to look at their overall interest. They have an advisory group organized under the SAC, the Space Activities Commission, which reports directly to the Prime Minister. This has a wide-ranging membership. As I indicated before, the Japanese interest and Japanese preparations in terms of the studies they've undertaken appear to be wider and more diversified than even in Europe or Canada, and that they have made a very conscientious effort to bring in a very wide-ranging group of people. Their mission analysis study has been completed. We have been briefed on it, generally speaking. We have not seen the document yet. At least I have not. They have identified a number of strawman missions—again, which related very closely to ones that Europe—or very similar to the ones that Europe has identified, as well as Canada. But, once again, with them, we have to talk more about prioritization and how those various uses need to be sequenced.

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Mr. PEDERSEN. Canada, similarly, has undertaken a joint government-industry study (figure 6). They have done the user requirements portion of that study. The cost-benefits analysis of the assessment of alternatives is currently underway. They have not provided us—we have not received that from them yet. The assessment of alternatives, I think, is an important point. This is also a case with Europe, where, as part of their studies, they have, I think, again out of good old self-interest, looked at not only what space station could do for them, but what their alternatives are to a space station. And, in Europe, that, of course, has taken the form of looking at greater upgrading and use of Ariane, an unmanned

automated space station, perhaps serviced by Ariane, the Eureca unmanned platform perhaps in clusters, a variety of options—and also the use of spacelab hardware on a more permanent basis in space.

I think it is very healthy that they look at these alternatives. I think that one of the things we have found in international dealings is that the concept that may have existed in the early 1970's when we were talking about the space shuttle and ultimately spacelab, and the arm, in which you were dealing with something—at least in the so-called freeworld, you were dealing with something akin to what I would call a hub concept with the United States in the center, and everything having to run through the United States because we had essentially a monopoly on launch capability and a very sizeable lead in the number of the technologies, has been replaced by a somewhat more, dare I say distributed architecture or a dispersed architecture. That is because the capabilities abroad have grown, the experiences grown, the launch vehicle systems are proliferating, so to speak. Ariane exists in Europe; the Japanese have their N/H vehicles.

What we now find is that the variety of coalitions and options that are open to other countries is increasing. This is—I think this is not something that we need be surprised at. I think the move toward greater independence and greater automony is characteristic of developments we've seen in a number of other high technology areas. But, what it does mean is that these countries have alternatives to use of a space station and alternatives to cooperation with respect to the design and construction of a space station.

Canada, for example, has established a formal relationship with the European Space Agency. Japan will be opening next month, I believe, an office, a permanent space office, in Paris to deal with ESA and CNES. And the individual who will be running that office is the Japanese Space Agency official who has been stationed for 3 years here in Washington, so he's familiar with space and familiar with the United States.

I think these are small signs of the kinds of growing diversity that's available in terms of cooperative patterns. And I think the study of alternatives is not only healthy, but I think quite natural and understandable. I apologize for that slight digression.

With respect to Canada, they also are looking at alternatives, including the possible interest in a European unmanned space station. They have identified a number of proposals. Not surprisingly, they have a high emphasis on remote sensing. They have a very large country, very sparsely populated in a number of areas, and remote sensing is an extremely important technology to them, not only for resource management, but also for monitoring shipping lanes and the like. So a lot of their interest was in the remote sensing area. Also, as a possible R&D facility for continuation of some of the work they have begun in areas of robotics and materials processing.

One of the difficulties is that sometimes their interest—or their interest in remote sensing—leads them to prefer a high inclination orbit which may not be compatible with some of the other orbital requirements that a space station might have to serve. And they have flagged that for us. That is an important thing for us to con-

There are maybe other ways to solve their high inclination ne[illegible] including free flyers that are, in some way or another, tended by a space station or, in some manner, related to a space station. But it is this kind of thing that this dialog has helped us uncover and better understand in terms of user needs. And they also concluded that there was a strong requirement for human presence in space. Or to put it another way, that man can offer significant benefits or add a dimension to a space station relative to unmanned platforms.

I'm sure the committee will have some further questions on this, but that's the end of my prepared statement.

[Figures 1–6 of the oral presentation, plus answers to questions asked of Mr. Pedersen follow:]

Space Station Definition Activities

International Affairs Division

66

AUGUST 2, 1983

25th Anniversary
1958-1983

Kenneth S. Pedersen

GROUNDRULES FOR INTERNATIONAL INVOLVEMENT IN NASA PLANNING

- PARTICIPANTS UNDERSTAND THERE IS NO APPROVED PROGRAM
- PARTICIPANTS PROVIDE THEIR OWN FUNDING
- NO FORMAL AGREEMENTS
- NO COMMITMENTS
- RESULTS OF STUDIES EXCHANGED
- REGULAR INFORMATION MEETINGS HELD

FIGURE 1

INTERNATIONAL INTEREST IN SPACE STATION

- SUBSTANTIAL FOREIGN INTEREST EXISTS IN NASA'S SPACE STATION PLANNING EFFORT
- THIS INTEREST IS SELF-GENERATED
- OUR CLOSEST ALLIES ARE SPENDING THEIR OWN FUNDS ON INDEPENDENT SPACE STATION MISSION ANALYSIS AND PLANNING STUDIES
  - -- CANADA, ESA, FRANCE, GERMANY AND JAPAN ARE CONDUCTING SEPARATE, PARALLEL MISSION REQUIREMENT STUDIES TO COMPLEMENT NASA'S STUDIES
  - -- ITALY EXTENDED ITS TETHERED SATELLITE SYSTEM STUDY TO INCLUDE POSSIBLE APPLICATION OF TETHER CONCEPTS TO A SPACE STATION
  - -- THESE COUNTRIES ARE ALSO LOOKING AT WHAT CONTRIBUTIONS THEY MIGHT WANT TO MAKE, IF OPPORTUNITY ARISES

FIGURE 2

RESPONSES TO WRITTEN QUESTIONS SUBMITTED BY CONGRESSMAN VOLKMER DURING THE HEARING BEFORE THE HOUSE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS ON AUGUST 2, 1983, TO MR. PEDERSEN:

QUESTION LI-1:

If other nations are going to cooperate with us in designing and building a space station, what are some of the things you would expect them to provide? Do you expect to subcontract to them or sign cooperative agreements?

ANSWER LI-1:

To date, NASA has not entered into discussions with other countries on potential hardware contributions. However, a space station distributed hardware concept provides many opportunities for international cooperation that fall within some basic NASA groundrules for cooperation, e.g., definable elements for which another country has full responsibility and clean interfaces. Thus, items such as separate modules and platforms appear to be attractive candidates for cooperation. This cooperation would take place under cooperative agreements and not through subcontracting.

QUESTION LI-2:

Do you expect the Europeans to build their own space station if we cannot reach an equitable agreement?

ANSWER LI-2:

It is not likely that Europe would be capable now of building a manned space station similar in size and scope to the concept being studied by NASA. Europe is, however, seriously studying an unmanned, automated version of a space station as an alternative to cooperation with the United States. Were the United States to preclude foreign participation in its space station, the incentive for Europe to proceed at an accelerated pace would certainly be heightened. In addition, the dialogue between Europe and Japan on potential space cooperation is expanding, so it is possible that Japan, which has shown a great interest in the space station idea, would join Europe on such a venture.

QUESTION LI-3:

On your second chart entitled "International Interest in Space Station," you talk about the countries conducting separate, parallel mission analysis and planning studies. You list France and Germany separate from ESA.

a. Why, since they are members of ESA?

b. How much are these countries spending in equivalent United States dollars for their efforts?

c. Has their data been useful to the United States space station planning?

d. Are they posturing to build their own station?

ANSWER LI-3:

a. France and Germany are both participating in the ESA mission analysis study as well as looking at how a United States space station might fit into their own national space objectives and plans. Many European countries that are members of ESA also have national space programs of their own.

b. We estimate the funding by other countries on space station studies to total almost $5 million, which includes both government and industrial funding.

c. Since NASA perceives a United States space station as a user facility, data provided by these parallel mission analysis studies has been very useful to NASA in understanding the potential worldwide user community.

d. ESA is examining a European unmanned space station and some of the study work being undertaken is valuable for this effort as well as for possible involvement in a United States program. France has been the major supporter of a European approach, particularly as such a station would depend on, and thereby accelerate interest in, an upgraded Ariane launch system.

QUESTION LI-4:

You mention "prioritized scheduling required" in the general conclusions of their studies--

a. What does that mean in relationship to our missions?

b. Did they have many more missions than the work of our contractors and NASA in-house planning?

c. How do you propose to "further understand" their proposed missions you speak of in your general conclusions?

ANSWER LI-4

a. The missions listed in the parallel studies are in most respects unconstrained by budget or programmatic priorities. Therefore, the next step is for other countries to assign some priority to these missions, and give us a better idea of when these missions might take place. Then NASA should have a better understanding of

how these missions might fit into our overall planning schedule.

b. While the combined total of foreign missions is greater than the United States sum, we believe this is due to the fact that the foreign data needs to be refined further.

c. NASA plans to maintain the current dialogue with foreign space agency representatives to further refine and sharpen our understanding of their proposed missions.

QUESTION LI-5:

I notice in your presentation on Canada's effort, you mention "cost/benefit analysis."

a. Were they the only ones to perform such an analysis?

b. Has NASA performed a cost/benefit analysis? Do you intend to do one?

c. What were Canada's findings associated with their cost benefit analysis?

d. Is there data that is attributable to the United States effort as well?

ANSWER LI-5:

a. ESA also conducted a limited cost/benefit analysis.

b. A rigorous cost benefit analysis by NASA is not appropriate at this time since the analysis is mission dependent, and we are not in a position now to accurately assess the traffic that could be potentially handled by a space station. The systems definition program that NASA plans to conduct in FY 1985 and FY 1986 will provide a data base to assess the entire program.

c. Canada's analysis is still ongoing.

d. Canada has not yet presented us with the results of its cost-benefit study which is still in progress.

QUESTION LI-6:

Also under the Canada chart you state that they did an "assessment of alternatives"--

a. Can you elaborate on this?

b. Did ESA do the same thing?

c. Were there any cost figures available with this alternative planning?

ANSWER LI-6:

a. Canada is also assessing other means of satisfying its space objectives; i.e., free flyers, platforms, European space station.

b. Yes, ESA is also looking at other alternatives such as an unmanned space station, space platforms, free-flyers.

c. Canada's study on alternatives is still underway, so we have not received their results yet.

QUESTION LI-7:

Did any of the International Community address the question of a commercial venture by private interests?

ANSWER LI-7:

The foreign mission analysis studies surveyed potential commercial users in addition to government users, and some commercial missions were identified. None of the studies, however, are directed at an entirely commercial space station program.

QUESTION LI-8:

What do you see as the next step in dealing with the International Community on this issue?

ANSWER LI-8:

For the time being, NASA intends to maintain its dialogue with foreign space agencies, and continue to exchange planning information.

QUESTION LI-9:

Has the International Community asked for any type of commitments from NASA?

ANSWER LI-9:

Some of the foreign representatives with whom we have been meeting have indicated that it would be helpful to have some kind of NASA commitment as soon as possible. However, they are well aware of the fact that this is not an approved program, and that no commitments can be made at this time.

Mr. VOLKMER. Thank you very much, Mr. Pedersen.

At this time, we will start questioning under the 5-minute rule, and I will recognize the gentleman from California, Mr. Brown, if he has any questions.

Mr. BROWN. Let me ask you a technical question, which is fairly simple, but I have never thought it true. What is the Earth track of 28° versus a 57° orbit, and why do the Canadians like the one rather than the other? I think I suspicion the answer, but I'm really not sure.

Mr. PEDERSEN. Well, I think there's two reasons. And having given the two, I think I will defer to the experts who will then give you, undoubtedly, the right answer.

The higher inclination orbit is important because they have a lot of their territory near the poles, and the high inclination orbit is preferable for that. And second, the high inclination gives you the ability to make the remote sensing capability Sun-synchronous, which allows you to get preferred Sun angles.

Mr. BROWN. That would be for a polar orbit to make it Sun-synchronous.

Mr. PEDERSEN. Well, but it gives you preferred Sun angles, I understand. But, again, I really—perhaps Bob and John ought to respond to that.

Mr. HODGE. When you go to 57°, you cover a large part of the Canadian area; whereas at 28½°——

Mr. BROWN. The track goes back and——

Mr. HODGE. Yes.

Mr. BROWN [continuing]. Forth across the Equator and it covers more of Canada because it goes further north.

Mr. HODGE. Yes. At 28°, it doesn't come to Canada at all.

Mr. BROWN. Yes.

Mr. HODGE. The reason you might go to high inclination rather than to polar orbit is that you cover the Earth at different times of the day with each orbit; whereas, with a Sun-synchronous orbit, you are covering it with a crossing of the Equator at exactly the same time each day, and so you get the same sunning at each time. And it's really a tradeoff between those two as to how important it is to get a different sun crossing. They like the 57° because they get this variation of Sun angle as they go over Canada each time.

Mr. BROWN. Yes. All right.

Let me explore with you one much more difficult question. The space station in near-Earth orbit, low-Earth orbit, is an intrinsically fragile collection of assets and subject to destruction or disablement relatively easily, which raises the question of how we would pose to handle that eventuality.

I was in a panel down in Atlanta on Sunday at the American Bar Association on Space Commercialization and Development, and the question of insurance for the hazards of space was one of the elements in the discussion. And, of course, implied in all of this is the question of whether or not the space station is perceived as threatening to the Soviets, whether they might try to disable it, whether it has a defense or an offensive mission.

I'm sure you discussed these things with the DOD. But to a peacenik like me, it seems that the simple solution is to do as we did with Apollo-Soyuz; that is, to offer a cooperative program

where we have at least some investment by both sides and we both lose if there's any effort to disable or destroy it.

I'd like to ask you to what degree the planning and analysis of this project has considered these factors, and if you have reached any tentative conclusions thereon?

Mr. HODGE. Well, the question of vulnerability, survivability, is important to the DOD. And, in many respects, the business of safety, and so on, from either a civilian point of view or a military point of view, has to be divided into two parts. If you talk about a civilian system itself with some level of cooperation, there is the international space treaties that work on the principle you are talking about, mutual consent and importance——

Mr. BROWN. Well, we have the pattern of the Antarctic Treaty——

Mr. HODGE. Yes.

Mr. BROWN [continuing]. Which I think should be extended to a space platform.

Mr. HODGE. Yes.

Mr. BROWN. But I'm asking you whether or not that sort of approach has been given any consideration at all?

Mr. HODGE. It certainly has been part of the debate, but it has not matured to the extent of any policy deliberations at the moment. We don't know yet how we would handle vulnerability from the point of the military system, and that really is a question of either making it invulnerable or making it unreasonable to attempt to do something about it. They are the really sort of two approaches to it.

I guess the answer is there is no simple way to make systems in low-Earth orbit invulnerable, as, in fact, there is no simple way to make any system invulnerable with a determined enough aggressor.

Mr. BROWN. I don't think there's even a complex way to make systems invunerable. But I may be mistaken on that.

Mr. HODGE. That may be true.

Mr. BROWN. The question arises as to whether the DOD, which I'm sure is interested in your plans at NASA, and I'm sure you have liaison with them, is carrying on a separate mission analysis of their own for the platform and other facilities necessary to mount the space-based lasers and other things that they're working on.

If this platform is conceived as being a potential base for that kind of development, then obviously it becomes threatening to the Soviets. If they're carrying on another type of systems analysis aimed at their own platform, why the problem's a little different, but not much.

You wouldn't be able to respond to that.

Mr. HODGE. No. At the moment, we are working closely with the DOD in the development of these capabilities. As you know, they have stated that there are no specific validated requirements for a manned space station at this time. But that does not mean that they have stopped looking. NASA and its predecessor agency, NACA, has had a history of very close cooperation with the DOD. And, in fact, I think that that's been a mutually successful process, inasmuch as many of the technologies are useful for both military

ANALYSIS OF INTERNATIONAL MISSION ANALYSIS STUDIES

- FOREIGN MISSION SETS APPEAR THOROUGH, WIDE-RANGING
- STRONG OVERLAP IN THE AREAS OF SCIENCE AND APPLICATIONS
- GENERAL CONCLUSIONS:
  - -- THE MISSION SETS WERE GENERALLY COMPATIBLE WITH THE CURRENT SPACE STATION CONCEPTS
  - -- CONTINUED DIALOGUE NECESSARY TO FURTHER UNDERSTAND THE PROPOSED MISSIONS AND THEIR REQUIREMENTS
  - -- PRIORITIZED SCHEDULING REQUIRED

FIGURE 3

EUROPEAN SPACE AGENCY

- UTILIZATION STUDY:
  - -- IDENTIFIED AND ANALYZED EUROPEAN PAYLOAD CANDIDATES THAT COULD BE BENEFICIALLY SUPPORTED BY A MANNED SPACE STATION (DISCIPLINES AND ACTIVITIES SIMILAR TO U.S. STUDY CONCLUSIONS)
  - -- EVALUATED REQUIREMENTS DERIVED FROM THESE PAYLOAD CANDIDATES
  - -- FOUND HUMAN PRESENCE USEFUL IN ALL DISCIPLINES, BUT ESPECIALLY IN MATERIALS SCIENCE, LIFE SCIENCE AND TECHNOLOGY DEVELOPMENT
- OVERALL CONCLUSIONS OF EUROPEAN UTILIZATION STUDY:
  - -- PROMOTES SCIENTIFIC AND TECHNOLOGICAL PROGRESS IN EUROPE
  - -- ASSURES PAY-OFF FROM AND MAINTAINS CONTINUITY FOR EUROPE'S MANNED SPACE ACTIVITIES AND EXPERTISE (SPACELAB HERITAGE)
  - -- IN THE LONG TERM, OPENS THE WAY FOR INCREASED OPERATIONAL AND COMMERCIAL SPACE UTILIZATION
  - -- PROVIDES TO EUROPE THE POSSIBILITY TO EXPLOIT THIS POTENTIAL AND TO GAIN THE NECESSARY EXPERIENCE
  - -- IS COST EFFECTIVE
    - EUROPE ALONE COULD NOT AFFORD REQUIRED ELEMENTS
    - MANNED SPACE STATION IS COMPLEMENTARY TO UNMANNED SYSTEMS AVAILABLE IN EUROPE

FIGURE 4

JAPAN

- ESTABLISHED AD HOC COMMITTEE ON SPACE STATION IN AUGUST 1982 TO ASSESS OVERALL INTEREST IN A POTENTIAL U.S. SPACE STATION
  - -- ORGANIZED UNDER SPACE ACTIVITIES COMMISSION, AN ADVISORY GROUP TO PRIME MINISTER
  - -- WIDE-RANGING MEMBERSHIP: GOVERNMENT MINISTRIES AND AGENCIES, NATIONAL LABORATORIES, UNIVERSITIES, AND INDUSTRY
- MISSION ANALYSIS STUDY
  - -- USER QUESTIONNAIRE, SPACE STATION SYMPOSIUM, AD HOC MEETINGS, AND CONTRACTOR STUDIES
  - -- STRAWMAN MISSIONS DERIVED FOR CONCEPTUAL STUDY
  - -- PRIORITIZATION OF MISSIONS IS NEXT STEP

FIGURE 5

CANADA

- JOINT GOVERNMENT-INDUSTRY STUDY INITIATED TO EVALUATE CANADA'S INTEREST IN PARTICIPATION IN A U.S. SPACE STATION
  - -- USER REQUIREMENTS DEFINITION
  - -- ESTABLISH TECHNOLOGY AREAS THAT CANADA MIGHT WANT TO PURSUE
  - -- COST/BENEFITS ANALYSIS
  - -- ASSESSMENT OF ALTERNATIVES (I.E., EUROPEAN SPACE STATION)
- USER REQUIREMENTS SURVEY
  - -- IDENTIFIES 37 FEASIBLE PROPOSALS
  - -- LARGE EMPHASIS ON REMOTE SENSING (AGRICULTURE AND FOREST MONITORING; POLAR EXPLORATION)
  - -- VERY INTERESTED IN SPACE STATION AS R&D FACILITY (LARGE STRUCTURES ASSEMBLY, MATERIALS PROCESSING)
  - -- NEED FOR 57° INCLINATION MAY BE SATISFIED BY OTHER APPROACHES
  - -- STRONG REQUIREMENT FOR HUMAN PRESENCE IN INITIAL STATION (DEVELOPMENT, TESTING ASSEMBLY; MAINTENANCE, SERVICING, REPAIRS)

FIGURE 6

applications and for civilian applications. And I think NASA will continue in that close cooperation with both the civilian community and the military community.

Mr. BROWN. Well, it's obvious that the technologies are of major interest to the DOD. On the other hand, if they indicate a specific mission, you might ask them to pay for some of the work, and they wouldn't like that.

Mr. HODGE. That has to be worked out in the halls of the Executive and the Congress as time goes by.

Mr. PEDERSEN. Congressman Brown, if I might just add something with respect to your comment about cooperative approach with the Soviet Union.

Clearly, that is not right now a major factor in our planning. I think the potential exists. I think that cooperation has tended to historically be one that reflected and was very much influenced by the broader political climate. But, I do think that, even in the absence of the formal kinds of cooperation that you're talking about, the fact that the Soviets themselves have a space station in low-Earth orbit, that they intend to—have indicated that they intend to expand rather substantially, pretends to produce a mutuality of interest with respect to protection, not tampering, that kind of thing, obviously in the absence of all-out hostilities. But, I think there may well be some form of protection here just in the mutual interests that emerge from the kinds of investments that both countries are contemplating.

Mr. BROWN. You would think you could generalize that to all of our assets in space, but that doesn't keep DOD from going ahead very vigorously with antisatellite weapons development and other things of that sort.

Mr. PEDERSEN. Well, I think those kinds of protections may well not be adequate in and of themselves. That is not my area of expertise. But in the absence of anything else, it is one form of protection.

Mr. BROWN. During that period that we describe as détente, apparently analysts felt that we have a very successful and mutually beneficial relationship in the development of the Apollo-Soyuz project. And it, of course, needs another such similar period before we can consider closer cooperation on a space station, but it seems to me that there would be benefits that would be almost overwhelming from the cooperation since we have moved in different, but complementary technological areas, and since we would, in effect, be insuring each other if we were cooperating in the process.

I have no further questions.

Mr. VOLKMER. The Chair recognizes the gentleman from Florida, Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. Pedersen, has the international community asked for any kind of commitments from NASA?

Mr. PEDERSEN. That's hard to say, Congressman, what the international community consists of. Individuals who have met with us from the countries that we have been working with in these studies have indicated to us we would be extremely helpful to them if NASA were in a position, or if the U.S. Government were in a position, to begin talking in more specifics about what a space station

might be and how they might be involved. We've pointed out to them that the program does not exist, that, in the absence of that, we clearly could not make such a commitment, and they have indicated that they fully understand that, while reiterating that it would be nice to have a commitment as soon as possible.

So the long answer to your question is they have suggested to us it would be helpful to make a commitment as soon as possible, but an understanding that we're not in a position to do that now.

Mr. NELSON. Would we expect the Europeans or the Japanese to build a space station if we didn't reach an agreement?

Mr. PEDERSEN. That is speculative. I'll say the following: The Europeans have on the drawing boards as part of their long-range plan, together with the upgrading of Ariane to an Ariane 5, together with the Eureca platform, together with looking at our space station possibility, a plan for an automated space station that would be serviced by Ariane. The Canadians have been involved in those discussions with them.

As I indicated to you earlier, in the case of the Japanese and Europe, it may not be either/or. It may be that they would do it—that the Japanese and Europeans—could collaborate, although I hasten to add that I have no evidence of this, but I do have evidence to increasing dialog and institutional ties between the two. Would they proceed to do that if we did not give them the opportunity to participate or otherwise use our space station? I would have to guess right now that it would be a high likelihood that they would move toward something that would give them some of the capabilities that a space station like the one we envision would provide. But I must say that that is speculative.

There is also, of course, the possible option of some form of cooperation with the Soviets. The French have had some cooperation with the Soviets in the space station area, and we know that the Soviets have had discussions with other Western European countries about possibilities. Again, this is a political question, but it is not one that we can totally ignore.

Mr. NELSON. May I just offer a caveat from this one member as you proceed with these discussions. The United States has transferred technology to countries such as Japan only to find that it comes back and haunts us. And I would be very, very careful. That will be the line of my inquiries in the future, as we approach some kind of so-called joint venture, were that to be what you ultimately decide.

We have turned over technology under the name of free enterprise to the Japanese, through sale of that technology. The Japanese have been trying to buy our technology for the F–15, the F–16. We've done that in the past with the Delta. And I think we've just got to be careful that it doesn't—in the name of international goodwill—that it doesn't turn around and come back and slap us in the face.

Mr. Hodge, tell me what is the present Soviet space station, and how do you expect that station to change by 1991? What do you expect it to be in 1991? What is it today and what in 1991?

Mr. HODGE. That's going to be somewhat speculation on my part, but they have had in orbit the capability to put from three to five people in orbit and carry out many of the experiments of the kind

that we have talked about here—the materials processing and things of that kind. If I look to the future, they have recently put up another space station. My guess is that they will continue to increase that capability during that time.

Mr. NELSON. What is the capability now?

Mr. HODGE. I'm trying to remember. I think, the ability to take three to five people up at a time and perform experiments of the kind that we are talking about in a volume which is somewhat smaller than we're talking about here for the 1992 capability.

Mr. VOLKMER. Would the gentleman yield?

Mr. NELSON. Sure.

Mr. VOLKMER. Would that also include the ability to resupply and—

Mr. HODGE. Yes. One thing they have done, which is sort of unique, is that because they do not have a shuttle, then they have to find other means to resupply the system, they have a fully automatic rendezvous capability where they supply their logistics and transfer fuel and fluids across the interface for their reaction control system and for their life support system.

Mr. NELSON. Is that an unmanned——

Mr. HODGE. That's unmanned.

Mr. NELSON [continuing]. Resupply?

Mr. HODGE. Totally unmanned, yes.

Now, that is a capability we do not have. But on the other hand, at the moment, we do not need it because we have the shuttle. Sometimes necessity is the mother of invention and they have to do things a certain way. The fact that they have to essentially throw away transportation systems almost demands that they have that capability.

Mr. NELSON. What is this module that they have connected to their space station?

Mr. HODGE. I'm afraid I haven't sufficient information to—

Mr. NELSON. The Soviets have had a space station up since basically, what, 1972?

Mr. HODGE. Yes. Of course, we flew the Skylab in 1973, which was a significant capability. The one thing it didn't have was permanence, and it was not built on the basis of resupply and logistics. It had an end. The program finished when we ran out of supplies, essentially.

Mr. NELSON. Does Dr. Keyworth understand that the Soviets have had a space station up since 1972?

Mr. HODGE. I'm sure he does.

Mr. NELSON. Tell me how does the establishment of a space station, in your mind, affect the commitment for a fifth orbiter?

Mr. HODGE. I think there are two entirely different subjects. The question of further production of the orbiter is associated with the need to supply the transportation system. It's a straight demand-and-supply situation, and I think that, as the demand grows, the need will be apparent and we will commit to that necessity.

The space station is quite different. It is the commitment to a new capability. And I believe that the two subjects should be treated independently of each other.

The nagging concern with regard to the further production of the shuttle is associated with the maintenance of the production line as

much as anything else. And what we have to do is to very carefully juggle the potential demands against the actual demands, the maintenance of the production line and this different thing, which is a total enhancement of our capability in low-Earth orbit.

Mr. NELSON. Do you see any timeframe in which, with what you've conceptualized as a space station, that the shuttle, as we know it now, would be inadequate for the servicing and transportation, and that we would need to go to some kind of second-generation shuttle?

Mr. HODGE. There's no question that that has to be faced at some time. The shuttle, as presently designed, was set up for 100 missions. It has very significant capabilities which we see will be very, very useful to us throughout the end—throughout the century—as it presently exists.

Nevertheless, it was built on a set of technology which we understood in 1970. By the year 2000, that will be 30 years old. Systems do last that long, but I think we have to face the question of a new generation transportation system in that timeframe.

Mr. NELSON. John, when I last saw you, we were over at the rather upbeat conclave on the space station, and it had really started off in a really rather upbeat way with Jim Beggs statement that he thought that within the next 6 to 12 months, that the White House would approve, give the go-ahead for a space station.

Would you like to comment?

Mr. HODGE. I'm not going to disagree with my boss.

Mr. NELSON. What led him——

Mr. HODGE. I think we are moving toward a decision.

Mr. NELSON. What led him to that conclusion?

Mr. HODGE. Well, Mr. Beggs has felt, himself, for a long time that, if we went about the development with an understanding of why we wanted to do a space station and what capability we had to do that, that the next logical step would be proven to be a space station with the characteristics that we've talked about. The President asked us to do an interagency study on that subject, and we have not changed our mind as a result of that. We believe that the process will be persuasive.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. I now recognize the gentleman from New Mexico.

Before I do, I would like for the reporter to include the statement of the gentleman from New Mexico, immediately following my statement, his prepared statement.

Mr. LUJAN. Thank you, Mr. Chairman.

With the emphasis that we have not encouraged the Canadians, Europeans, and Japanese into proceeding with all of their space platform ideas kind of reminds me of when we lived in Santa Fe, our children had a little turtle. And it disappeared one time. This little girl whom we suspected had taken the turtle, as she is turning the corner, she runs into my wife, she says, "Mrs. Lujan, I didn't take the turtle."

So that is kind of the protestations that we hear. You're not encouraging them a little bit?

Mr. PEDERSEN. No. I'm not.

Mr. LUJAN. All right. Very good.

Following up on a couple of the themes raised before, with all the alternatives that these people are looking at—the Canadians, Europeans and Japanese—just kind of emphasizes to me the need to hurry up, because the more studies we do, the more advances we make, and that they find out about. They are going to proceed with this. They don't seem to have the constraints that we do, waiting for OMB and the Congress and everybody else to make up their minds. So the sooner that we put it up, it seems to me like the better off we would be.

Let me follow up a little bit, however, John, so that I can understand about 28½°. You're talking off the Equator?

Mr. HODGE. Yes. If you make a due East launch——

Mr. LUJAN. Yes.

Mr. HODGE [continuing.] From Cape Kennedy, that is at 28½° above the Equator. And, therefore, the subsequent orbit that comes out of that goes backward and forward across the Equator, reaching a maximum inclination of 28½° above and below the Equator.

Mr. LUJAN. That's kind of confusing. I, whenever you're talking—I didn't understand until, as a matter of fact, now when you were talking with Mr. Brown about it. I looked at 28½° on the compass, and I thought, well, you know, how can 37° be more North than 28½°? So I think you complicate things. Couldn't you call it 180° plus 28°, 208½° or something like that so that us poor folk could understand it?

Mr. HODGE. I apologize for the jargon of us technical people. It is not good, and we're not explaining those things, but I will be very happy to get together with you.

Mr. LUJAN. OK.

I had always thought, and I am rather surprised—at 28½°, does that put it in geosynch?

Mr. HODGE. It can be done at geosynchronous orbit. The 28½° is merely the inclination to the Equator.

Mr. LUJAN. I understand that.

Mr. HODGE. It can be at any altitude. Geosynchronous happens to be a place where it apparently stays above a given point on the Earth, because it is so high that it takes exactly 24 hours to go around the Earth.

Mr. LUJAN. And is that the intent of the space station?

Mr. HODGE. The space station we're talking about right now, the 28½° one, would be at an orbit compatible with the Shuttle, which brings you to about 150 to 200 miles.

Nevertheless, we do see the need for assets at geosynchronous orbit which would need to be tended by the space station system. And that is where the requirement for the high-energy upper stage that we call an orbital transfer vehicle—now, we have such vehicles right now, of course. The Centaur, for example, is a high-energy upper stage, but it is expendable—we throw it away each time—and it starts from the ground.

There are significant economical advantages to having those high-energy capabilities permanently in space and reusable.

Mr. LUJAN. Pull that around to 200, wouldn't that be geosynch anyway?

Mr. HODGE. No. You have to go to 22,000 to get geosynchronous, or thereabouts.

Mr. LUJAN. Yes.

So that to do—the word that keeps coming is surveillance, but I don't mean that—mapping of the Earth, if that's one of the functions that it's going to serve, you would not want it at geosynch then?

Mr. HODGE. No, that's not quite true, because as you go further away from the Earth, you get a larger view of that particular hemisphere of the Earth. And, as you know from pictures of the meteorological satellites, that you get a view of the complete Earth from that position, but you can only see one piece of it. So you need several of them in order to cover the whole Earth under those circumstances.

Mr. LUJAN. Are we talking about just one then?

Mr. HODGE. No. It is possible to do Earth resources type surveillance from geosynchronous altitude, but——

Mr. LUJAN. But only to one side of the Earth.

Mr. HODGE. Only to one side. But what you would have to have is a system of them, three of them, to get the whole Earth. The problem there is that now you are 22,000 away; you can't see things in such detail as you could from low-Earth orbit. So it's a tradeoff between the way you approach the orbital mechanics of it.

Mr. LUJAN. Yes.

In the evolution of the space station, do you see it evolving into the Government not operating it at some point?

Mr. HODGE. That's an interesting question. It is my firm belief that within a relatively short time—let's say another 25 years—there will be significant assets in space which are wholly owned by commercial ventures, and something like a space station, I think, is not only possible, but very likely. Nevertheless, I see that, in the business of developing technology and enhancing technology, that there will be an appropriate Federal role.

Mr. LUJAN. Yes.

Mr. HODGE. And over the next 25 years, we have to work out what that role is, and it's not going to be simple to do. And it is not going to be easy to accept, I think, of a purely commercial function, but I think it is going to happen, and I think it's appropriate.

Mr. LUJAN. Well, probably what could happen is much like happens in the aeronautical research of NASA that really has immediate private company involvement or benefit, and still we continue the research effort. And I don't think that anyone's talking about—about the Federal Government getting out of the research business completely, but those things that are operational, there is a reluctance on the part of many of us to have the Government be operating any facility, whether it is in space or here, that couldn't better be done by private enterprise, or at least better in the sense that it's not costing us anything—anything to do.

Mr. HODGE. I think it's very appropriate that we tackle that problem and make it possible for commercial interests to operate. We already do with the communications satellites. I think that that's an analog of what the future is going to be like. And I am sure Mr. Wood will talk to you about that, from Booz, Allen.

Mr. LUJAN. The final thing is that—I suppose you know that in this committee and in the entire Congress, my way of looking at it, there is a lot of support for a space station, and we just hope that

the administration moves quickly to make—to make that decision, because I know you are ready for it. Some of the research that we see going on in preparation for a space station, how you build it and all of those things are moving along. I just hope we move along as quickly as we can.

Mr. HODGE. We appreciate your support, sir.

Mr. LUJAN. Thank you, Mr. Chairman.

Mr. VOLKMER. All right. I now recognize the gentleman from Virginia, Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

I would judge from what I am hearing that were Mr. Beggs or others even further in the hierarchy to say, "Mr. Hodge, should we go forward with the space station, what is your view, you would respond affirmatively."

Mr. HODGE. Yes, sir.

Mr. BATEMAN. It is, therefore, apparently constraints, budgetary primarily, that have to this point delayed the decision, or is it a competition between other priorities in terms of space programs or projects as they impact upon budgetary constraints?

Mr. HODGE. I think it's both of this, and quite properly so.

I think the debate we are in the middle of—and it will include both the executive and the legislative side—is associated with both fiscal constraints which are appropriate and with priorities. And I think it's one of the geniuses of this system of government that they get discussed appropriately before decisions are made.

Mr. BATEMAN. There was some intimation that other countries didn't have these kinds of problems as they looked to prospects of doing these things. I rather suspect that's not entirely true. Would you comment on that?

Mr. HODGE. I think the debate takes place at a different level, and the public may not be quite so aware of the debate. But I am absolutely certain that it takes place.

Mr. BATEMAN. Now, in your presentation—I'm a little bit better at words than I am at technology—and you use the terminology "user transparency" and "technological transparency." And while I thought I knew what transparency was, I'm not sure I understand it in either of those contexts. Would you explain how you mean it?

Mr. HODGE. That's another term of art I must apologize for. What we mean by technology transparency is the ability to change the technology in situ without tearing the thing apart and starting again.

For example, supposing we wanted to convert carbon dioxide to its constituent parts, carbon and oxygen. What we want to be able to do in the initial design is to be able to plug something in in orbit without help from the ground, and do that when the time comes, when the capability to do it is available. And we call that transparency, from a technology point of view. We do not want the system to be dead ended by the inability to introduce new technology as time goes by.

Mr. BATEMAN. Might I suggest technological versatility or something that says it more nearly like what you just said, than transparency, which I wouldn't even relate to what you just said?

Mr. HODGE. Again, I apologize for our jargon.

Mr. BATEMAN. In the discussions of the international interest, again, I'm bothered by words, the Italians and their tethered satellites. I though Indians tethered ponies. What is a tethered satellite?

Mr. PEDERSEN. A tethered satellite, Mr. Congressman, is a project that we are currently discussing with the Italians, and very shortly will be signing an agreement. It is a concept that will be used first with the shuttle. It involves a satellite suspended on a long line, like a fishing line that can be reeled up and down from the shuttle. Hence, the concept of the satellite being tethered.

The idea is that from the altitude of the shuttle, you can lower—well, there is no up or down in space—but you can drop the satellite into the upper atmosphere and get certain samplings, as well as do a variety of kinds of experiments, and then easily bring the satellite back into the shuttle. It removes the necessity of doing the very complicated rendezvous and retrieval.

It is quite an ingenious concept. And the Italians will be doing the satellite portion and NASA will be doing the tether and the reel. The Italians are looking at whether that concept of a satellite on a line that can be raised and lowered, so to speak, would make sense also in the concept of a low-Earth orbiting space station.

In this case, "tether" may not be the perfect word, but I think it does conjure up the concept.

Mr. BATEMAN. It sounds very good, very descriptive.

How long is the tether conceptually?

Mr. FREITAG. Up to 100 miles.

Mr. BATEMAN. A hundred miles. And that would get you——

Mr. FREITAG. It could be longer if you keep going up higher, but the one that's being built is around 100 miles.

Mr. HODGE. It is a very big fishing reel.

Mr. BATEMAN. Yes, it sounds—it sounds——

Mr. FREITAG. Well, the fishing reel is probably as big as this table, and inside the payload bay. And the line is a very thin line. It is probably the diameter of a match.

But there's no forces on it because there's no great drag or gravity moving on it.

Mr. PEDERSEN. I'd have to say, Congressman——

Mr. VOLKMER. Would the gentleman yield? Would the gentleman yield just for a—I just talked to counsel here about this. The thing that's always intrigued me about the tether is that, if it's released at the time when the shuttle is in orbit, and you release it out of the payload bay, what's going to make it start dropping?

Mr. FREITAG. Actually, you will give it a little push with a spring, and the spring will start it moving toward——

Mr. VOLKMER. In other words, it will be upside down, the shuttle will, and there will——

Mr. FREITAG. The shuttle will be upside down and the payload bay looking toward the Earth. You will have a release mechanism which has a spring in it that will start it moving, and it will start unwinding. Once it gets a very short distance out from the bay, then the phenomena which is known as gravity gradiant begins to work, which says that the pull on the tether is greater than the pull on the orbiter, and it keeps on pulling out until you stop it.

Mr. VOLKMER. Thank you.

Mr. BATEMAN. Mr. Chairman, if I might proceed, I would suggest to my friends at NASA that they not let me near this device, because there is a gremlin who follows me around and, if there's a rod and a reel, it gets tangled.

Mr. PEDERSEN. First backlash in space.

Mr. BATEMAN. Mr. Pedersen, you made reference to the Canadians, ESA, other European and the Japanese conducting separate studies complementing NASA studies. That suggests to me that there is a very considerable amount of discussion, because if their studies are complementing our studies, it would almost seem to be that there is a coordinated exploration taking place. Does it go that far?

Mr. PEDERSEN. Well, I think what you have to put it in terms of is what is being studied. Yes, there is a coordinated study. Coordination tends to imply a very formal institutional arrangement which doesn't exist. But they're complementary in the sense that they are looking at the same types of questions our studies are looking at. And these are the mission requirements for a space station. That is, what could a space station with an assorted set of capabilities do in terms of their objectives for their missions? How would it assist them in remote sensing missions? How would it assist them in perhaps communication, in materials processing, and so on?

So they are complementary in that we are trying to look at the same sets of questions in the relationship of what I indicated earlier, a user orientation. Our intent is to see a space station that would be—that would have customers, that would have users. And if you're going to do this kind of work, I think, in a good, efficient, free-enterprise mode, one does a bit of market surveying.

In a way, without trying to stretch the point, it's a little of what these studies are involved in. What is the market? How would it be used? Is it consistent with plans? You hate to think about building something and then find out it isn't compatible with what the entire rest of the world space programs have been looking at. But what we have not done is to go the next step, which would then begin to say, OK, are there aspects of the space station you would be interested in participating in in a hardware or development sense? That is what we have not done. And there is no coordination in that respect at this point.

Mr. BATEMAN. References are made—if I might ask a final question, Mr. Chairman—to interaction discussions with the Department of Defense, and very appropriately so.

My question is: Has this produced sort of a mission specific reaction from the Department of Defense as to what they would be looking for and what their particular objectives would be, insofar as the space station is concerned?

Mr. HODGE. Not at the moment, sir.

The question of military men in space has been studied for a long time, as you know, and we have made many starts—the dinosaur program in the early days of the space program, the MOL program was another one. And on each occasion, the DOD has decided that there is no significant role for man in space that cannot be better achieved or more economically achieved by an unmanned system. They have worked with us very closely this year, and they

still come to the same conclusion with regard to military men in space. Nevertheless, the question of these technology development missions is one which is still open, and I'm sure, as it always has been between NACA and NASA and the military, there will be mutual advantages to that kind of program.

Mr. BATEMAN. In other words, I take it then that the focus of the Department of Defense has not been in terms of, so to speak, a weapons system or the deployment of a weapon, not as a direct military application, but the acquisition of data and technology that may have its spinoffs in terms of necessary significance.

Thank you.

Mr. VOLKMER. Thank you, Mr. Bateman.

To go along with John with—Mr. Lujan got into the question of commercialization. In the event that the Congress or the administration or both would decide that man's presence in space is not really needed at this time and that we don't wish to go along with it after, let's say, another year of studies, do you believe that the commercial sector, the private sector in this country, would move ahead with proposals for, say, a space station, a manned space station?

I can see free flyers and things like that for limited use, but an actual manned space station.

Mr. HODGE. There have been tentative steps on the parts of various groups to talk in terms of such a development. I think it is going to be very difficult for them to develop the venture capital to prove that in fact such a thing is possible. Very often, the commercial interests are going to get on board that kind of thing when they know that the risk is relatively low. And really the purpose of R&D, I think, particularly Federal R&D, is in many respects to reduce the risk for the commercial enterprises.

Mr. VOLKMER. Aren't we still a ways short in the field of technology and life support systems, et cetera, being able to transfer people, et cetera, that's going to be necessary to utilize man's presence in space? Aren't we still far short in technology?

Mr. HODGE. I think we are on the very edge of it. I don't know as I could answer that one completely black and white. I think it will be some time before commercial ventures will be prepared to go out on their own, independently of the Federal Government. But I think that's going to be a very interesting debate over the next couple of years.

Mr. VOLKMER. Well, I'm not saying in the future we wouldn't be prepared.

That gets me to the next question that was also brought up. And it appears from the schedule and everything that we are looking like the 1987 fiscal year before we really get into hardware.

Mr. HODGE. Yes, sir.

Mr. VOLKMER. Is that the reason is we just don't want to push it up faster because of budgetary restraints, or is it because we need to further study it and we need to further develop technology for it?

Mr. HODGE. From my personal point of view, I think that that is the most appropriate earliest time to start cutting hardware. I really believe that we should understand this very clearly before we commit to hardware. And, 1987 is an appropriate time.

Mr. VOLKMER. In other words, what you're saying to me is that, even if we had plenty of money right now to spend, we wouldn't be ready to go.

Mr. HODGE. That's right. I would like to be cautious about the definition process. And that's particularly true with regard to the development of these special technologies which allow evolution to take place. I really believe that we need to do some solid technology work, the testbed work and the flight tests, along with the design process. That will just make us much smarter about what we build. And I think we need that next 2 years or 3 years to do that.

Mr. VOLKMER. Now, as I understand your charts, you're talking about for a space station costs for initial capability from $7.5 to $9 billion. Now, what does that include?

Mr. HODGE. Remember the chart I showed that had a manned element which had somewhere between six and eight people in it? It has two attached land modules to do R&D which will be materials processing, some assistance to the commercial group, attached devices which will allow you to attach unmanned things to it, the ability to service unmanned satellites, and teleoperator maneuvering system to go along with that. That's the sort of manned element and its attendant things. And two large platforms, one for astrophysics at 28½°, and for Earth resources viewing at sunsynchronous orbit.

Mr. VOLKMER. Now, are we talking about the TMS development expense is included in that?

Mr. HODGE. Not the development of the TMS as a straight carrier. I expect that that development will have to take place as a natural evolution of the space transportation system. What we normally——

Mr. VOLKMER. That is not included in the $7.5 to $9 billion?

Mr. HODGE. That's right, sir.

Mr. VOLKMER. Neither is the OTV?

Mr. HODGE. No. But, what is included with regard to TMS in that $7.5 to $9 billion is to change it from a ground-based system to a space-based system—that requires some modifications—and the development to a front end to the TMS which would allow us to do remote operations from—sort of a telepresence type of thing. It really an enhancement of the robotics capability.

Mr. VOLKMER. All right.

Does the $7.5 to $9 billion include any operations money?

Mr. HODGE. No, sir. It includes the operations money associated with the construction of the facility, and I think that that came out to be about five shuttle flights. It does not include the continued operation. That is carried under the operations budget NASA. And from what we can tell, covering a similar number of missions, one way or another, that the addition of space station will not change the total operations costs for NASA over this timeframe, unless the number of missions themselves increase. Now we see them increasing in the commercial area, in which case, that will tend to be a wash, from a budgetary point of view, because they will be cost reimbursable.

Mr. VOLKMER. From $7.5 to $9 billion, to keep with that so I understand, does that include all of our studies in phase B, et cetera?

Mr. HODGE. No, sir.

Mr. VOLKMER. Does not include any——

Mr. HODGE. That's the DDT&E area. The definition period, as I mentioned, is somewhere between 5 and 10 percent, and would be prior to the commitment of the DT&E funding. This is the DDT&E funding.

Mr. VOLKMER. OK.

How much—how much above that—or have you figured anything—first, I'll say, how have you figured anything from the commercial side or the private sector side in that $7.5 or $9 billion?

Mr. HODGE. We have not included in that things which would be totally owned by commercial interests. We have included a piece of one of the labs where commercial products could be taken through the research and development phase. We have assumed that if we come to free-flying factories, or factories which are attached to the manned module, that they would be provided by commercial interests in addition to that set of money.

Mr. VOLKMER. That's what I was wondering—in any of these platforms that you show on that, or any of those to be provided by the commercial or private sector.

Mr. HODGE. Not in the plans that we have at the moment. We believe that there will be satellites, free-flying satellites, provided by the commercial industry, but in addition to that. The difficulty we would have in even participating in such a discussion is to estimate the potential growth in the commercial area. We believe that that's up to them to do that.

Mr. VOLKMER. Now, how do we—or how do you plan to continue industry involvement or user involvement in the continuing design studies?

Mr. HODGE. We have set our organization up in such a way that, with regard to the user involvement, we have one piece of our organization will be continuously working with those, briefing them on where we stand on the design and receiving their requirements back from them during the whole design process, throughout the design process.

Now, with regard to industry, there are really two kinds of industry. One is the commercial side, which is through the user involvement side; the other side is the aerospace industry. As you know, they were involved in the mission analysis studies that were completed in April. Congress supplied us with appropriations which allowed us to continue with industry to the tune of about $4 million in 1983, and $14 million in 1984. We will use those funds to continue to bring industry in. But in addition to that, what I have done is to provide every opportunity we can to get the views of industry, to have them participate with us in conferences and, as I mentioned earlier, they were particularly useful to us in the amalgamation of the mission requirements in the May timeframe.

I believe it is extremely important that the views of industry are understood and, by the time that we have designed this, that they will know what it is we want, that they will have bought into the process that we have established, and I think that those are two prerequisites for the construction of the facility because, in the long run, this will be constructed by industry.

Mr. VOLKMER. Do we anticipate involvement or cooperation with, let's say, the domestic side, or even the international side, when we get into phase B?

Mr. HODGE. Do you mean from the point of view of industry?

Mr. VOLKMER. Yes.

Mr. HODGE. Well, of course, the phase B——

Mr. VOLKMER. Or the international side, too, if we have the question of the European space community continues, you know, interest, et cetera.

Mr. HODGE. Ken and I are in the middle of those discussions right now as to the way that the international community would participate in the phase B study. We have not come to any conclusions yet, except that they must be continued to be informed as we go along.

Now, with regard to whether they would do something which was separate from what we are doing or apart of what we are doing is something that needs to be discussed in the strategic sense to make sure that the problems that Mr. Brown was talking about, and Mr. Nelson, that this technology transfer is a rational thing. We hope to come to conclusions about that process by the end of this year. With regard to the substance of actual participation, we are planning to have those conclusions by October 1984.

Mr. VOLKMER. In other words, there is the possibility of more than just cooperation by us with them and letting them know what we are doing and everything.

Mr. HODGE. Yes, sir.

Mr. VOLKMER. There is a possibility of full—some participation by them into it also.

Mr. HODGE. I think possibility is exactly the right word, yes.

Mr. VOLKMER. All right. They are not foreclosed, but it's not decided yet that it would be either.

Mr. HODGE. That's correct, sir.

Mr. VOLKMER. How much input are we receiving from what I'd say those scientists more involved with interplanetary matters in this space station? Do we have any involvement there at all?

Mr. HODGE. Yes, sir. We have taken special care to work with those groups, and I'll tell you what we have done to date.

In the first place, we have continuous discussion with the Office of Space Science and Applications. We have two full-time persons on the task force from that organization, and that dialog is extremely good.

In addition to that, I have made presentations to the Space Science Board which, as you know, is an arm of the National Academy of Sciences, during every meeting they've had over the last year. They are somewhat skeptical, but, nevertheless, are listening and participating and making sure that whatever we do, their requirements will be met. That includes both the people interested in low-earth orbit things and the planetary people.

Mr. VOLKMER. The skeptism is involved with whether it is having applications to interplanetary exploration?

Mr. HODGE. The skepticism is really associated with whether the space business is a zero-sum game from a budgetary point of view, and whether any attempt to increase the manned program in NASA would, in fact, steal from those things.

I personally don't happen to believe that that's the way it works. They have been concerned and quite vociferous in the parts about the fact that they do not want their program to be foreshortened simply because of the presence of the manned program.

I should say that I have also had a similar arrangement with the Space Applications Board and, as recently as 2 weeks ago, briefed those people.

Mr. VOLKMER. Mr. Pedersen, on the assessment of alternatives that Canada did, can you give us any more detail as to what data assessment—in other words, what conclusions they may have arrived at from that assessment?

Mr. PEDERSEN. No. That assessment is underway right now, Mr. Chairman, and we don't have that final assessment. We do know the alternatives they're looking at involve, obviously, the use of unmanned platforms rather than manned, free flyers, possible cooperation in a European station of some type, as well as cooperation with us, but have not received the final evaluation.

Mr. VOLKMER. Has there been any discussion on the international sector as to if there was participation as to involvement monetarily?

Mr. PEDERSEN. Yes, of course. We have talked about informally some ground rules that, were we to enter into a cooperative arrangement as opposed to utilization arrangements, what that might look like. And I think earlier Congressman Nelson used the phrase going into this as a gesture of international good will or something. Let me indicate to the committee that if we ever have to come and defend to you an international agreement solely on the basis of international good will, I hope it's not me that has to do that.

We would tend to approach this, and we assume the other countries are approaching it, in terms of basic self-interest. And one of the things we have made very clear to them—and I think they understand that—is that we would expect that if we enter into a cooperative arrangement, that this would involve them developing the hardware, the system, the component, in a way that maximized what we call clean interfaces, the kinds of contribution where the technology transfer would be minimized, and that this kind of involvement on their part would continue to involve the use of their funds, and that we, in turn, intend to use our own funds in the development of our portions of the space station.

One of the most difficult questions here, Mr. Chairman, if we move down this road, is in the area of quid pro quos, what would be their return for the development of this hardware and its contribution, shall we say, to the space station. Would it be in the form of specialized access, special rates? There would clearly have to be quid pro quos discussed.

One of the quid pro quos we are not discussing is subcontracting abroad or sending U.S. dollars abroad to make large hardware purchases. I think that would be probably unwise policy, politically, economically, and I don't anticipate that that is what they are expecting either.

Mr. VOLKMER. Well, couldn't it be possible in the future that you have something similar to what we now have—we're getting ready to go up to the spacelab—whereby the international community or

Canada or Japan or anybody else could develop that type or part of a space station and that we could here, in conjunction with that, do the technologies as far as the life support system, compatibility with ours and everything else? But as far as the integral part of it, they could make a decision, and they could even develop that part?

Mr. PEDERSEN. Well, I think that one thing that makes the space station a potentially attractive opportunity for international cooperation, if the other concerns could be worked out, is that the types of architecture now being discussed, the so-called distributed architecture that could involve a collection of platforms, modules, and so on, is particularly well suited to separable contributions to a variety of cooperative possibilities, where the interfaces are relatively clean, where you are not talking about joint hardware development where technology transfer does become a concern.

And I think it's very interesting that some of the developments we see going on in Europe, for example, with the Eureca platform, as well as the work they've done with spacelab, has produced hardware and expertise closely related to this. And I think that they would view that as a potential cooperation—pattern of cooperation and contribution they could make.

Again, the difficult question is: "What would be their return? What would be the benefit to them out of such a contribution?" And I think that's an area where a lot of discussions would be required.

Mr. VOLKMER. You may get to the point where you may have a German firm or a French or somebody else wanting to get involved in materials processing and have something you want to send up, and they want to have a manned presence in order to handle it. I'm sure that those type of things can be worked out.

Mr. PEDERSEN. We hope so.

Mr. VOLKMER. I have no further questions.

Mr. BROWN. May I just make one comment, Mr. Chairman?

Mr. VOLKMER. Yes.

Mr. BROWN. This discussion of mutual benefits versus—well, leads me to comment that I know of no situation that builds good will better than one which provides mutual benefit. It will frequently be the case, if the benefit is one-sided, you don't build good will anyway. And our whole system of enterprise is based upon one of good will arising out of both sides profiting from it. I think we ought to continue that, as far as the space program is concerned.

Mr. PEDERSEN. Mr. Brown, I would not want the record to show that the witness came out against international good will. My comment was related to the fact that I think that good will has to have a substantive basis. And I couldn't agree with you more, good will tends to be basically engendered by self-interest, finding its root in mutual benefit.

Mr. VOLKMER. One last question, John. Do you envision any difficulty in obtaining the funds that you're going to need for fiscal year 1985 to continue on with the studies and designs?

Mr. HODGE. I'm sure we will go through the process in the usual way, and we'll have the proper amount of questioning. I think we know clearly what we want to do, and we'll be coming back to you in February of next year and discussing that subject.

Mr. VOLKMER. Well, you're to need a little more money then you got in 1984?

Mr. HODGE. That's something we have to look at very carefully, particularly with regard to the continuing participation of industry.

Mr. VOLKMER. Right.

Mr. HODGE. And the 1-year delay in the industrial participation in the design effort is something that we have to look at very carefully, and I'm sure we will be discussing that with you next year.

Mr. VOLKMER. We'll have some additional questions that we'll submit in writing. We would appreciate your reply as soon as possible.

Mr. HODGE. Yes, sir.

Mr. VOLKMER. We'll hold the record open for that purpose.

Thank you very much, Mr. Hodge, Mr. Pederson and Mr. Freitag.

Mr. HODGE. Thank you, sir.

Mr. VOLKMER. Our next witness is Peter Wood, senior vice president of Booz, Allen & Hamilton.

Mr. Wood, I wish to welcome you here this morning. We have received copies of your statement. Your statement will be made a part of the record verbatim. You may either proceed with reviewing the statement or with summarizing, however you so desire.

Mr. WOOD. Mr. Chairman, in the interest of time, I will summarize briefly and, a little later, I'd like to use five viewgraphs to help illustrate a couple of the points, if I may.

Mr. VOLKMER. Yes; proceed.

STATEMENT OF PETER W. WOOD, SENIOR VICE PRESIDENT, BOOZ, ALLEN & HAMILTON, INC., ACCOMPANIED BY MYRON WEINBERK, BOOZ, ALLEN & HAMILTON; AND PETER STARK, BOOZ, ALLEN & HAMILTON

Mr. WOOD. I appreciate the opportunity to appear before the committee. I'm pleased to represent Booz, Allen & Hamilton, Inc., which, as you probably know, is a worldwide professional consulting firm consulting in management and technology. And for the last 20 years, we've consulted in space matters, and we are especially interested to have a small role in the early thinking that might lead to a space station project.

Before we go on, I'd like to introduce Dr. Myron Weinberk on my right, my distinguished colleague who has worked with me for the last 2 years, and particularly during the space station studies, and has had a strong role in the science activities and in interfacing with user industry. And he is also available for questions. With me also is Mr. Peter Stark with my staff at Booz, Allen.

We first got interested in this sort of activity about 2 years ago under a different name. At that time, we did some independent work on something called a space industrial park, working with some NASA individuals. And we ascertained at that time through some rather limited contact with industry that there was interest in such an activity that might provide, through some Government activity, a place to work in space, and that firms would be interested in committing resources to preparing the work in space, and

perhaps providing some part of the investment necessary to form such a platform itself.

We talked to some members of Dr. Keyworth's staff, and there was some interest there. But, generally, it didn't seem the right time to go ahead.

So, finally, in 1982, the rebirth of the space station idea came along under NASA offices, and the studies that you've heard about performed by the eight aerospace contractors began. Booz, Allen was a subcontractor to McDonnell Douglas Astronautics, one of those eight contractors. And our responsibility had to do with making contact with user industry and doing some benefits analysis. And each of the eight studies involved some of this user contact. In NASA's view, the work of Booz, Allen was deemed to be the most effective of that sort.

And we did, in fact, identify that there were people in industry who were very interested, but that it took some rather special techniques to unearth this interest, a rather unique approach in which our Booz, Allen team, looking at the various attributes of space that would be important, developed some seed concepts so that we would go out with a story to tell with something that would spark interest, rather than saying what would you like to do in space.

And this turned out to work. For each of these seed concepts, we worked at identifying the right firm to put that concept before, in terms of firms that had the resources to take a little risk perhaps, firms that were forward looking, and that would understand the story we were telling. In some cases, these were firms where Booz, Allen had access because our clientele includes a large part of U.S. industry and European industry.

The firms we've contacted, for the most part, have been U.S. industry, some small business. But in one case, we're carrying on an active dialog with a British-based corporation that has a U.S. arm.

So we did find that there were people receptive to the idea of talking to us. Sometimes we would enter through a senior executive who could commit the firm's activities. In other cases, we might begin with an executive who ran the research arm of the firm. But, usually, two different kinds of contacts were important.

And then we would meet with these firms individually and present the seed concept, and sometimes there would be reaction to that, where they'd discuss it and think it was a good idea, or in other cases, we might trigger a different idea where it's kind of a brainstorming process.

There were a number of instances where there was concern that the discussions themselves might produce proprietary ideas. So, in these cases, we executed agreements with these firms, with the blessing of NASA. NASA, and in the early phases, McDonnell Douglas Astronautics, both were quite liberal in permitting us to work in this way, so that we could uncover ideas and interests and foster interest, but still protect the rather delicate state of such emerging intellectual property.

And I think it is fortunate that we were able to work this way. We've come to term this general process buffered access, because it was access to firms and to the ideas of their best people in this shelter of an agreement and some privacy. But in many cases,

what we've learned has been reported in the results of those first-phase studies, and much of that work is continuing.

One of the points we made to NASA, and the other firms also did, was that once you've stirred up this kind of interest, it's very important to nurture it, keep going, especially at a stage where there is no program and there's nothing to believe in. So you might want to call this hand-holding, but we persuaded NASA that it was important to continue this sort of dialog, and to keep the shingle out for new parties to step forward and say that they were also interested.

So, in fact, NASA found a little bit of money to compete another phase of user contact, and Booz, Allen won a small contract, and we're now in about the third month of a 9-month effort to continue this development of interest in nonaerospace industry. And along with that, we've been a little more active than before in public pronouncements, a few press conferences, platform appearances, papers published.

And because the more forward-thinking members of the media have taken an interest in this sort of activity, the word has gone abroad and people are coming forward with additional ideas, or people are coming forward to ask what they might do. So this has broadened what was a fairly small effort because of that personal one-to-one nature of it.

And we're excited about what we're hearing out there, and we now believe that there is enough interest and there is enough potential economic gain for industry to come forward.

I think it's important at this point to note that, along with interest, we found some problems out there.

Let me have the first viewgraph, please.

[Slide 1 shown.]

Mr. WOOD. There were concerns expressed by industry, and these concerns translate into obstacles in many cases. And because they are obstacles, we think they deserve a little attention.

We classify the concerns or obstacles in three categories, as you see on this exhibit—technical barriers, economic barriers, and some concerns related to working with the Government. This is the sort of thing that comes up every time, and it has again this time. But let me go through the technical ones first of all.

Next one.

[Slide 2 shown.]

Mr. WOOD. First of all, people don't know much about phenomenology in space. They don't know what happens when you take an earth-born process and start playing with it in an environment of microgravity and a vacuum, and there is still a lot to be learned about that in terms of what happens to cells and what happens to physical and chemical processes. And there's still some more science to be done about this. So there are a lot of unanswered questions, and this is one of the barriers.

The second point there is that we people who have been bound to the surface of the Earth since we were born, or before we were born, think instinctively in terms of what happens in a one-G environment, the kind of environment we all have grown up in. And we don't have to give much thought to what happens when you pick up something and let go—it drops.

Well, to suddenly translate the thinking of well-trained scientists into trying to picture the same processes in space is a difficult thing. And this, in fact, is a barrier, and none of us is perfect at it yet. The few pioneers who have worked in space are beginning to find out how it works, and they've learned to carry out the normal tasks of living in space for a period of even months very well.

But this is a small barrier that has to be dealt with. And I think the knowledge will proceed in rapid fashion once we begin to work at it a little bit more than we have. It's still a young subject.

There are risks, and it's not possible for anybody to under—immediately identify all those risks and how to manage those risks. And that becomes a bit of a problem. We'll talk a little bit later about that under economics also, but the technical risks are what we're talking about here. They need to be managed, and they need to be foreseen as best you can.

Again, our time in space has been limited, and we just don't know all the problems that are going to arise.

I mentioned human capabilities and endurance. This is something that the United States is behind the Soviets on—time for man in space—I think by a ratio of something like 3 to 1. We don't really know what kind of training it will take to put technicians in space, to oversee the processes and the logistics associated with them, and keep them motivated over a period of perhaps 6 months work in space.

Maybe it's a little bit like the problem of motivating a submarine crew when we're talking about the 50th submarine that's going to operate for a long time, and they're not in the spotlight anymore, and glamour isn't quite there. Maybe it's a little bit like motivating people that work on the North Slope.

But a lot of work needs to be done on human endurance and motivation and how man works best, what kind of equipment and tools he needs, what kind of food he needs, what does he need for his morale and entertainment—a lot of work there. People worry about this. That's one of the barriers.

Competing technologies is a matter that we see some question about. We might interest somebody in this process of working in space, and they might begin to develop a process optimized for the microgravity environment and by the time there's an operational space station—let's say 1991 we're talking about for the initial capability—and they're ready to fly their moneymaking production process, somebody may have figured out a way to do what they're doing on Earth with some other process, or somebody may find a way to manufacture a different substance that can be substituted for the substance they plan to make in space.

So that's another kind of risk or barrier or concern that people look at. Should they go that long haul until return on investment, or are they taking a chance that they'll be undercut by technology or by some other process?

The last point showing here is the question of intellectual property rights. I mentioned earlier that this was a concern in the first conversations.

It's also a concern when these firms contemplate putting a process in a space station module next to that of another firm, or per-

haps where there is visibility on the part of other countries. They need to know how their proprietary processes will be protected.

Next, please.

[Slide 3 shown.]

Mr. WOOD. Under the matter of economic barriers, the subject of this exhibit, there are a number of, I think, fairly obvious thoughts, but they are raised.

First of all, it does cost a lot of money to work in space, and it will cost quite a bit to prepare the equipment and materials and to do the research to put something into space. The process will take some time.

McDonnell Douglas Astronautics has done a lot of work on the process called electrophoresis in space, joined by their partner, Johnson & Johnson. We've all heard about this. It's a very dramatic and exciting story. And we believe that it will soon pay off in terms of product, return from space with a very high value. We believe that this sort of investment will meet many issues that the country faces in terms of health and communications and other subjects, and it's part of the value.

But you have to look at cost—high cost, a lot of risk associated with that investment, uncertain return, probably a long payback period if you're there early. You may have to worry about your stockholders or your investors, do they think you've gone bananas and started spending money in some crazy way. That's something that the decisionmakers always address and think about. What will the backers say? Can they be convinced?

I've listed some of the cost factors here, and I think they're fairly obvious, and I won't go through them.

But I want to emphasize the bottom line here is the bottom line. There needs to be a fair return on investment. People are now talking about getting into business with the Government, and sometimes that means constraints.

I think that we need to realize that there is risk, and there is a long payback period, a lot of uncertainties, and pioneering going on. I think it needs to be known that the Government understands that there should be a fair return on that investment.

There's some other issues, such as the fact that people with the kind of money to do this have alternative uses for that money. There's the question of timing. Do you do this early when the risk is highest and the return is longest, or do you take a chance on being second and maybe missing out on some of the best niches that are opportunities? So that's an issue that industry faces, and I think a little help from the Government may be appropriate in dealing with these issues.

Next, please.

[Slide 4 shown.]

Mr. WOOD. I told you that the last category we talked about has to do with the Government, working with the Government, the kind of concerns that arise at this point.

Again, these are things that come up in many other programs where industry is working with the Government, but they do need special attention because there will be more of this sort of obstacle raised, and they will keep people out of the game. There are many firms out there in nonaerospace industry that we're talking to who

have never worked with the Government—except at income tax time perhaps—they are not in regulated industries, and they have a lot of concerns about it.

I mention first-timers here as the first point. Yet, these first-timers have wonderful ideas. They probably have a lot to bring to the matter of making money in space and making space a factor in the economy of the United States.

The second point is what I mentioned a minute ago, their concern about the Government's attitude on fair return on investment. The bureaucracy can be pretty forbidding sometimes. You just try to phone the Government with a little question sometime, and you may get passed from one place to another to another. Well, some of these people have had a little bit of experience with that. In particular, a few firms have tried to enter into a joint endeavor agreement with NASA, and they have some specific knowledge that it's a difficult thing to do.

I believe there are now two such JEA's in effect, and I am told by the president of one small business that it really took him about 3½ years to get to the point of having a signed agreement for this joint endeavor, which means activity where neither firm is handing money to the other firm, but each is providing some activity in kind. And the activity might be a payload carried in the space shuttle to test out the idea.

But that's one small example of how forbidding a bureaucracy can be, and there are many more that could be cited.

Something we hear a lot about from other industries such as shipbuilding and the like is the instability of Government programs, and also Government policies. If we're talking about a gestation period for a space station of 8 years and to a larger capability of space station something beyond that, then there's a special need for stability. We're talking about asking people to invest with a return way off in the future.

We need to try to find ways to stabilize this. I know it is difficult for one Congress to commit the next Congress, and that's an aspect of what I'm talking about. But even more important is stability in the Executive department and its Cabinet departments.

The electorate is right now probably very interested in space. Will it still be interested in 5 years when there's still some time to go before the initial operating capability of a space station? These people don't know that. And none of us can promise that either. But I think a well-conducted program with some interim successes will help assure that.

Several of you have asked questions today about the role of DOD. And it appears today that DOD has not identified a requirement for space station. But nevertheless, some of these user firms, as we call them, wonder about whether there will be a military presence on a manned space station, and whether that might mean that they're kicked off at some point when they're counting on revenue or whether their logistic launches in space shuttle will be preempted by a military requirement.

So, if there is no military character to space shuttle, I think that would be a little more popular with most, at least on this point.

The international aspects are similar. If there is international investment in a whole module, will it be possible for U.S industry to

be making a profit on that module? These are questions that are not well defined in that case.

And, finally, there are those who say that a program like space station may not be carried to fruition because some will challenge it as drawing down on research and development funds of other kinds that might otherwise go to research centers and universities. And I think they need the assurance that both programs will go forward in healthy fashion, and that that will not really be a competition.

Next, please.

[Slide 5 shown.]

Mr. WOOD. Well, what do we do about all this?

We've suggested here a few suggestions for ways to counteract these concerns and make sure that they do not become obstacles.

First, some science needs to be done on a continuing basis. And NASA has a little science budget, but I think more questions need to be inquired into and answers need to be made available to industry. In fact, more awareness work of all kinds needs to be undertaken so that nonaerospace industry is reached through the media, through the kind of contacts we made, but on a broader scale than we've been able to undertake on the very limited budget that we've had to operate with.

Second, these people will need help. They may need to be led to help in terms of understanding how you work with space hardware. Many of them have no knowledge of space hardware. They don't understand, for example, where the power comes from that supplies their process, and they need to understand how that works, and what other services will be provided in space, how to configure their packages to best go into something that can be orbited by shuttle and mated up with the space station.

They need help on interfacing with the space business. What are the procedures? What are the resources available? We know that resources are available on technical help through NASA centers, as well as through aerospace industry. But there needs to be some pairing up of nonaerospace firms with people who have these technology resources.

There needs to be a more simplified interface with government—and I think I've said enough about that—protection of intellectual property, and stability to the Government programs. The most important kind of stability will be the recognition by the administration and by the Congress of space station as a program, as represented by corporations dedicated to this program. And people will then become much more able to have faith in the coming space station and more willing to invest their time and thought and resources in preparing to be tenants on such a station.

And, finally, one of the things you've heard John Hodge say something about is the value of an intermediary role, such as the role that Booz, Allen & Hamilton has been playing during the current contract and the previous subcontract. Somehow, it may be very helpful for firms to have somebody to talk to before dealing with the Government, where they can talk in a sheltered environment, where they can explore with an objective entity what the possibilities are, where, if you like, they can ask dumb questions without embarrassment. Some of the things that people not work-

ing in space ask are quite understandable. But people are a little embarrassed about doing this, and they don't really want to go to NASA with some of these questions, so that may be an important aspect.

Off, please.

I think that it's clear that U.S. preeminence in space will well be supported by such a program. We believe very firmly, on the basis of our experience, that sometime 10 or 15 years from now, man's presence in space will begin to form a very important part of the U.S. economy.

Finally, as we've suggested, and other studies have shown, there are a lot of issues that the United States tries to deal with, such as the economy and communications and health—some of the diseases that need to be tackled—can well be served by such a program. And we're very excited about the prospect, although we were conservative at the outset. Having talked to some of the leading firms throughout the United States, we now believe that they're ready to go and that they just need cooperation and a little help from the various appropriate elements of the Government, and certainly including NASA, which I think has made a very thoughtful start on thinking out what this program should look like.

I appreciate the chance to talk to you today, and I would be pleased to answer questions.

[Slides 1–5 of the oral presentation, the prepared statement, plus answers to questions asked of Mr. Wood follows:]

COMMERCIAL USER CONCERNS

CONCERNS OF USERS CAN BECOME OBSTACLES:

- **TECHNICAL BARRIERS**
- **ECONOMIC BARRIERS**
- **GOVERNMENT-RELATED CONCERNS**

BOOZ·ALLEN & HAMILTON INC.

SLIDE 1

COMMERCIAL USER CONCERNS (CONTINUED)

TECHNICAL BARRIERS:

- **LACK OF KNOWLEDGE ABOUT IMPLICATIONS OF SPACE ATTRIBUTES AND PHENOMENA**
- **POOR ABILITY TO CONCEPTUALIZE PROCESSES IN SPACE AND MICROGRAVITY**
- **RISK IDENTIFICATION AND MANAGEMENT**
- **HUMAN CAPABILITIES AND ENDURANCE**
- **COMPETING TECHNOLOGIES — TECHNOLOGICAL OBSOLESCENCE**
- **INTELLECTUAL PROPERTY RIGHTS**

STATEMENT OF PETER WRIGHT WOOD
Senior Vice President, Booz, Allen & Hamilton Inc.

Mr. Chairman, members of the House Subcommittee on Space Science and Applications, I am Peter Wood, and it is my privilege to represent Booz, Allen & Hamilton Incorporated in your overview hearing on the status of NASA's Space Station activities.

As I believe you are aware, Booz, Allen is a leading professional services firm consulting in management and technology to Government and industry worldwide. This includes nearly twenty years of consulting in space systems management and technology, for NASA and Aerospace industry. I am a senior vice president of the firm, and have been with Booz, Allen for sixteen years, principally in defense and space activities.

I should like to introduce my distinguished colleague Dr. Myron Weinberg, who has worked with me for the last two years on the scientific and industry aspects of Space Station. Formerly with Booz, Allen, he now heads his own consultancy.

Our activities today began two years ago when we worked, in cooperation with the NASA Staff, in developing a concept of operations for a Space Industrial Park. We discussed this concept with a few U.S. firms in such industries as chemicals and pharmaceuticals and found positive indications of interest and willingness to invest in participation in a Government-initiated project to provide a place to work on orbit. We found signs of interest in the staff of the President's Science Advisor, but it seemed the time was not right for a new space initiative.

Then in 1982, NASA renewed its studies of a manned Space Station that had originally figured prominently at the start of the shuttle program. Others have told you of the concurrent Space Station Needs, Attributes, Architecture and Options (SSNAAO) studies carried out under contract to NASA by eight aerospace firms. Each was to include the identification of missions, and especially commercial users and their "missions" or applications. Booz, Allen was a subcontractor to McDonnell Douglas Astronautics, with the primary function of user development and a unique approach.

Rather than a wholesale form of contact with industry such as mass mailings or large seminars, we used a tailored, one-on-one approach that proved quite effective. From the

attributes of space, such as microgravity and vacuum, we segmented the possible fields of commercial activity, relating to metals, biological materials, crystals, chemical, glass -- as well as services that might lead to business. We postulated seed concepts centered on industrial processes where the product would be high in value, would have a significant potential market, and would be differentiated from products produced on earth -- by higher quality, purity, or output quantity -- or perhaps could not be produced on earth. We then selected the appropriate industry and firm to which each concept should be communicated, and identified initial contacts, often within Booz, Allen's clientele. We arranged meetings through well placed executives and senior research personnel. Some such meetings could take place only under agreements to protect intellectual property - a process we call 'buffered access'. Disclosure of our seed concepts often sparked a flow of creativity, from which one or more feasible ways to use space emerged. In those cases where commitment to serious investigation of possible commercial activity resulted, our effort became worthwhile.

From the best of these contacts came representative mission concepts and related requirements for support that helped the aerospace contractors to assemble requirements -- for available power, crew size, logistics needs, configuration, and access. These requirements, combined with those of non-commercial missions, were aggregated to form a basis for the initial capability Space Station.

More importantly, the positive reaction of some of the firms gave us confidence that there was sufficient economic potential to attract investment from U.S. industry (as well as European industry). Promising opportunities involved biological processing, production of high performance catalysts, a fee-for-service laboratory in orbit, and the production of high purity iridium crucibles for the production of gallium arsenide, needed in high speed electronic switching.

It was apparent that continuity of contact with promising users was important to fanning sparks of interest, and that many more candidate users need to be identified. NASA, encouraged by the progress in user development, awarded new contracts for continued user development, and Booz, Allen is now three months into a small 9-month contract. We are contacting 25 of the more promising firms identified under the SSNAAO requirements studies (Coopers and Lybrand is following up on another 25), and we are also carrying on a modest awareness program to supplement our seed concept efforts in attracting new interest. Media

interest and resulting inquiries have been quite encouraging. We now find that, in addition to candidate user firms, we are being contacted by new space venture firms or subsidiaries, many proposing vehicles or free-flyer platforms that might compliment early Space Station modules, and by venture capital firms, which have begun to show a marked interest in commercial activity on orbit. We have identified a dozen major investor firms with such serious interest.

Our target is commitment by several well qualified firms to efforts that will lead to prototypes flying in shuttle. Entry into Joint Endeavor Agreements (JEA's) with NASA, enabling such flights, would be a positive indicator. Toward such an end, Booz, Allen is in communication with some 35 user firms or teams. We believe that the interest is there, the investors are ready, and that the economy of the nineties will see industry in space as a new, important element. Early successes will lead to greater activity. One such early success is likely to flow from the landmark work of the McDonnell Douglas and Johnson and Johnson team, working under a JEA with NASA. Prototype flights in shuttle have dramatically demonstrated the great potential of their electrophoretic separation process.

But our discussions with industry have also highlighted concerns on the part of would-be users. In many cases these concerns constitute obstacles to commercial development of space, so I'd like to identify some of these user concerns. They can be viewed in three areas:

- Technical barriers
- Economic barriers
- Government-related concerns.

Under <u>technical barriers</u> come:

- A lack of adequate knowledge about implications of space attributes and phenomena -- unanswered scientific questions
- Poor ability of many to conceptualize processes in space and microgravity
- Unknown risks, and a need for ways to manage risk
- Inadequate knowledge of human capabilities and endurance in space, and issues related to staffing work in space
- Competing technologies that might overtake the development of an orbital industrial process

before it can pay off -- or obsolescence of the product to be produced. Will indium phosphite displace gallium arsenide before we get our Space Station module on stream?

- Issues concerning intellectual property rights.

Economic barriers include the high cost of putting a successful process on orbit, the risks to the investment, an uncertain return, a long payback time, and image problems with backers. The return must justify the risk, the investment, and the wait. And there are questions of alternative investments, and the correct timing.

But most often we heard of concerns related to the Government:

- First-timers worry about doing business with the Government
- They worry about whether the Government will allow a fair return
- The bureaucracy is forbidding; it can take from one to three years to get a JEA approved
- Government programs and policies are viewed as unstable, and,
- The electorate is fickle
- Some worry about military preemption of their place on the Space Station
- There are concerns about whether international participation in developing and deploying Space Station will prevent U.S. industry from profit-making use of the facility - or private U.S. ownership of a module
- There are worries about opposition from those who see Space Station drawing down on R&D funding.

Finally, there is a need to know whether Congress will put constraints on private, profit making ownership of a module, or on the encouragement of investors who might turn out to be competitors of a Government function.

A similar catalog of concerns at last month's Space Station Symposium triggered wide industry agreement that

such Government related concerns were a key factor in reluctance to invest in space.

Because of the promise of commercialization of space, and its relevance to many national issues, we believe it is vital to stimulate, facilitate, and assist industry in moving toward commitment and investment. Some solutions have surfaced:

- Outreach is needed - to inform, provide answers, do the science needed, remove the mystery
- Assistance - find ways to help firms in non-aerospace industries to explore possibilities, make use of space technology, work through procedures
- Provide a simplified interface with the government, and response times appropriate to entrepreneurial style.
- Enable protection of intellectual property and proprietary processes
- Bring stability to government policies, programs, the rights of commercial users -- and establish a credible Space Station program with well-thought-out industry access
- Provide for the services of an intermediary, to ease the approach of industry to the government space program.

U.S. preeminence and success in space will result from creation of a supportive, cooperative environment for commercialization. I commend the Subcommittee on Space Science and Applications for its foresight in taking up this subject.

We believe the Space Station, properly planned and effectively executed, will be of great importance to the prestige, economy, and well-being of the Untied States. We appreciate the opportunity to testify today, and would be happy to answer any questions.

BOOZ, ALLEN & HAMILTON INC.

Peter Wright Wood
Senior Vice President

AUGUST 31, 1983

Response to questions from House Subcommittee on Space Science and Applications on NASA Space Station activities:

Q1. You initiated your program of user development via a one-on-one approach with potential companies/industry.

a. Have you maintained the one-on-one or have you been able to move to larger groupings in providing information etc...?

A1a. We have maintained the one-on-one approach with nearly all of the users with whom we are dealing. This has been necessary because companies are generally acting only for themselves and dealing with proprietary concepts, and introducing additional parties to the discussions would not be appropriate. An exception to this has been our work in developing the concept of a privately owned and operated Fee-for-Service Laboratory as a component of the Space Station. In this effort we have been talking with over a dozen venture capital firms and at least two commercial laboratories about the general idea, and are considering the possibility of gathering a number of them in one place for a formal discussion and possible team building. We believe the group approach is only likely to be appropriate in situations such as this where no company is likely to be able to pursue the idea by itself (for both technical and financial reasons), and where it might be useful to have several potential competitors considering the opportunity at the same time.

Q1. b. Have you found compatible ideas in your search where despite "buffered access" you could bring the ideas together -- for improvement, modification, etc...?

A1b. We have had at least one instance where we were able to bring two independent, confidential concepts together to create a joint concept that improved on each of them alone. While both of these ideas are covered by confidential agreements, the resulting concept has not been adopted by either party as yet, though for reasons unrelated to its merit. We believe that this is an important function which can be provided by a third party intermediary, and we continue to watch for opportunities to make such improvements.

Q2. What is the process of a JEA? How do the potential commercial customers view the JEA?

A2. While NASA is perhaps the best source of the specifics steps necessary to negotiate a JEA with NASA, we can address the general nature of the process and the way potential users view it.

From the user side, the primary prerequisites are interest in a

specific concept and the willingness to commit to signing an agreement with NASA. If these are present, then the company can approach NASA and attempt to negotiate the terms of an agreement. Under the general form of a JEA, no money changes hands between the company and NASA -- where the proposed effort so justifies, NASA provides free transportation and technical assistance for hardware compatibility and integration during the development phase of the concept, while the company provides for building the necessary hardware, conducting all ground development and testing, and processing some samples for NASA along with its own.

Potential non-aerospace users we have contacted generally are not familiar with either the JEA or the other types of agreements available. The companies who presently are working under JEAs with NASA feel the process of negotiating the agreement was too long and drawn out, and NASA is attempting to remedy this through the work of its Commercialization Task Force. When potential users are introduced to the concept of the JEA and the other available agreements, they seem to view them as an opportunity to simplify and shorten the development process, while hoping that the process of negotiating one can be improved over the first ones. There does not appear to be any significant discontent with working under a JEA once it has been negotiated, and this offers some hope to future participants.

Q3. Has Booz, Allen had any success in reducing the three concern areas mentioned?

A3. Booz, Allen has had some success in reducing the barriers in the areas of technical and government, while the barriers in the economic area tend to be somewhat outside our ability to influence them directly. The JEA (see Question 2) offers some relief to the cost barrier by providing for shuttle transportation without cost.

In the technical area, we have been able to have a significant impact on both the level of understanding of the attributes of space and the ability to conceptualize processes which take advantage of them. Our awareness program of talks, press conferences, and papers has led to several companies contacting us to explore possible space development programs, and our use of seed concepts and one-on-one meetings with companies has stimulated the development of new concepts in which the companies have both ownership and interest in pursuing. In addition, our ability to protect confidential information and ideas has greatly enhanced our ability to gain access to companies and stimulate their interest in otherwise proprietary areas. At the same time, it has given the companies access to our own and NASA's expertise in the space field without their experiencing concern over discussing confidential information with a government agency.

In the area of government-related concerns, our role as an intermediary has helped to alleviate the concerns of firms who have not dealt with the government as directly before, and has given them a source of guidance and expertise in approaching the idea of entering into a working agreement with NASA. In addition, our

close association with NASA in general and the Space Station and Commercialization Task Forces in particular has permitted us to provide up-to-date insight into the rapidly developing NASA policies and programs which most concern potential users. This provides users with first hand information on the positive steps NASA is taking to facilitate the commercialization of space, and gives them confidence that their interests will be taken seriously and dealt with promptly. We are confident that the work of Mr. Evans and the Commercialization Task Force at NASA Headquarters will greatly simplify working with NASA and will lead to tearing down manyu government-related obstacles.

In the economic area, the steps NASA is taking to work with companies and both simplify and reduce the cost of access to space are the most positive ones that can be taken at this time. Booz, Allen's role in this area has been to communicate the nature of these steps and the ways in which they reduce the costs and risks associated with working in space, and show interested companies how favorably space opportunities can compare with other alternative investments. The continued work of NASA and the companies who are already developing space missions will provide the evidence necessary to reduce private sector concern in the other economic areas we mentioned in our testimony.

Q3. a. Is it too early to speculate on the technical aspects?

A3a. Beyond the technical barriers addressed above, it is too early to evaluate such concerns as human capabilities and competing technologies. As with some of the economic concerns however, the continued work of NASA and the early private users of space will serve as the best illustration of whether these concerns will turn out to be serious impediments to commercialization.

Q3. b. Are there any solutions you mentioned being used by NASA to remove these concerns?

A3b. To one degree or another, NASA is either using or investigating the use of all of the solutions we identified. Through our contract with the Space Station Task Force, they are providing for extended outreach and an awareness program, direct assistance to interested companies, a simplified interface with the government, and buffered access to protect proprietary information. In addition, under the same contract with the Space Station Task Force, we are studying the various alternatives for providing the services of an intermediary, and will recommend a specific approach at the completion of this phase of the contract in January.

In addition, NASA's Commercialization Task Force is developing an agency-wide approach to stimulating the commercialization of space, for completion by the end of December. This will provide a NASA Commercialization Policy and a plan for implementing that policy in the agency, including the structure and responsibilities of whatever organization is to lead NASA's commercialization effort. The development of this policy includes consideration of the use of an intermediary similar to the one being studied by the Space

COMMERCIAL USER CONCERNS (CONTINUED)

ECONOMIC BARRIERS — HIGH COST, RISK, UNCERTAIN RETURN, LONG PAYBACK TIME, IMAGE WITH BACKERS. COST FACTORS INCLUDE:

- **PLANNING**
- **R&D**
- **DATA**
- **PROTOTYPING**
- **SYSTEM MATERIALS**
- **INSURANCE**
- **TESTING**
- **PROCESS MATERIALS**
- **PACKAGING**
- **TRANSPORTATION UP/DOWN**
- **SPACE STAFFING**
- **BURDENS AND ADMINISTRATION**

PLUS A RETURN TO MATCH THE RISK AND DELAY.
OTHER ISSUES — ALTERNATIVE INVESTMENTS, TIMING

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SLIDE 3

COMMERCIAL USER CONCERNS (CONTINUED)

GOVERNMENT-RELATED CONCERNS (OF NON-AEROSPACE USERS):

- FIRST TIMERS IN GOVERNMENT BUSINESS
- GOVERNMENT ATTITUDE ON FAIR RETURN
- THE FORBIDDING BUREAUCRACY — AND THE HURDLES TO A JEA
- INSTABILITY OF GOVERNMENT PROGRAMS AND POLICIES
- THE FICKLE ELECTORATE
- THE SPECTRE OF MILITARY PREEMPTION
- INTERNATIONAL ASPECTS
- DRAWDOWN ON GOVERNMENT R&D FUNDS

SOME SOLUTIONS

GOVERNMENT AND INDUSTRY SHOULD COOPERATE TO NEUTRALIZE CONCERNS AND OBSTACLES

- **OUTREACH – INFORMATION, ANSWERS, MORE SCIENCE TO SOLVE SPACE PHENOMENA MYSTERIES – MORE AWARENESS WORK**
- **ASSISTANCE – TO FIRMS EXPLORING POSSIBILITIES, FORMING CONCEPTS, UNDERSTANDING SPACE SYSTEMS CAPABILITIES, INTERFACES, PROCEDURES, TECHNOLOGY MATTERS**
- **SIMPLIFIED INTERFACE WITH THE GOVERNMENT**
- **PROTECTION OF INTELLECTUAL PROPERTY**
- **STABILIZED POLICIES, RIGHTS, PROGRAMS – ESTABLISHMENT OF A FORMAL SPACE STATION PROGRAM**
- **AN INTERMEDIARY**

BOOZ·ALLEN & HAMILTON INC.

SLIDE 5

Station Task Force.

Finally, of course, NASA is moving forward with its development of a space station concept, and if a formal Space Station Program is approved, that will provide a strong signal to the private sector that NASA, Congress, and the Administration are serious about the commercialization of space.

Q4. How many foreign countries have expressed a keen interest in the commercial aspect of a space station?

A4. NASA is probably in a better position to give a complete answer to this question than we are, particularly in terms of the governments which may have expressed interest, but we are aware of the participation in recent space station planning by Germany, Italy, France, Japan, and the European Space Agency. For our part, we have two inputs that we can offer. First, one of our leading candidates to enter into a joint agreement with NASA to develop a space mission is a British firm, Johnson Matthey Inc., whom we originally contacted through one of their offices near Philadelphia, but who is evaluating alternative concepts in their research facility near London. Second, we were visited by two gentlemen from the German Aerospace Research Establishment (DFVLR) who were interested in our approach to stimulating private sector interest in hopes of duplicating our success in Germany and throughout Europe. We believe there would be interest from other European companies if we were to approach them in the same manner as we have companies here in the United States.

Q4. a. Would the involvement of foreign industries substantially reduce the market for our own industries?

A4a. While this is difficult to assess with any certainty, several things should be considered. First, foreign companies or industries will undoubtedly enter the market eventually, either by following U.S. leaders into the same markets, or by pioneering in new markets. In either case, any market would soon become international in scope once several competitors have entered it. Second, it would be very difficult (diplomatically and otherwise) to restrict foreign access to space, either by limiting access to the shuttle or commercial expendable launch vehicles, or by charging a premium to use a U.S. space station. Access to space can be obtained by upgrading Ariane to a manned capability, dealing with the Soviets for launch services, or (in a more limited way) by using remotely operated platforms and delivery systems. The use of a space station could be provided by purchasing the components from the same companies who build them for NASA, or duplicating its functions via foreign sources. Third, while U.S. companies have somewhat of a jump on foreign competition, there are probably sufficient foreign capabilities and resources to make up enough ground such that the long term effect on the market will not be significant. And any market that is big enough to attract early investment is probably large enough to accommodate several competitors, regardless of their nationalities. Thus, the fact that some of the future competition will be foreign is not likely

to effect the development of the total world market for any particular product or service.

Q4. b. Would the participation of foreign industries be encouraged to help pay for the space station?

A4b. This question should be referred to NASA, but the issue of foreign participation and/or access to U.S. orbital facilities is one that will probably be decided by Congress and the Administration, and not by NASA alone.

Q4. c. What are the possibilities of creating a truly international space station from day one? That is, through the research/development to construction to the use of the station?

A4c. A truly international space station is clearly possible if NASA, the Administration, Congress, and the public feel that one should be attempted. An international space station program would certainly be more difficult to negotiate, manage, and share operational responsibility for than a domestic one, but it would appear to be feasible. It also might cost more in total, but might have a lower portion borne by the U.S. than a 100 percent American approach. Such an exercise of U.S. leadership would serve our foreign policy well.

Q5. In your list of possible solutions you suggest an intermediary between industry and government?

a. Where exactly would this intermediary come from?

A5a. To be a true intermediary in the context in which we envision it, an intermediary would have to be a non-government entity, and free of the influence of any particular company, industry, or interest group. We are currently operating as such an intermediary on a short term, limited resource basis, on NASA funding. The ultimate format of such an intermediary is under study now.

Q5. b. How would he/she serve to "ease the approach" between government and industry?

A5b. The intermediary "eases the approach" between government and industry by providing several functions which each lacks. It provides the government with the services of an organization which understands the government's requirements and the way it works without actually being the government. It provides the user with someone who understands the user's technology, the way his business operates, and the competitive forces which control his actions and his markets. By understanding both sides, the intermediary makes it easier for each to approach the other with a better idea of what to expect and thus a better chance that its needs will be satisfied.

In many ways, the situation is not unlike that of a person going to court - he would feel a lot better if he had a lawyer who could tell him what to expect, understood his problems, and knew what the

process was all about. While the adversary nature of the courtroom is absent, the security provided by a lawyer's knowledge of legal procedures and his understanding of his client's situation and interests is very similar to that which potential users need in dealing with NASA and the government. By understanding the government and its requirements, and the user's technology and the way it does business, the intermediary makes it easier for a user to approach the governemt without the concerns he might have otherwise, and permits the government to identify and work with users who are most likely to benefit from working in space.

Q6. How do you propose to bring the stability to government when the Administration can change within a venture lifetime?

A6. Perhaps the only way to bring the stability to government which industry needs to see to allay its concerns in this area is for the government to enter into agreements with companies or groups of investors to provide certain facilities or capabilities by a certain time. If such agreements could not be broken by simply cutting the budget in future years, then industry could have some assurance that the government would live up to its end of the bargain. Also, if the prospect of the government failing to meet its obligations to private industry was offensive to a large enough section of the business community, then political pressure could possibly be brought to bear to force the government to live up to its commitments.

Q7. Did your firm provide NASA with a list of major investment firms with serious interest in space? Or is this data considered proprietary?

A7. We have not provided NASA with a list of the major investment firms with whom we are dealing who have expressed interest in making investments in space. While we have mentioned some firms by name, those mentioned have generally been those which NASA already knows to be interested from other activities. While the identity of the other firms is not proprietary, the preliminary nature of our discussions with these firms is such that we feel that disclosure at this time could hamper the chances for success in the future, while also damaging our position as an intermediary.

Q8. How do you feel about commercialization of a space station by the private sector?

A8. We believe that ultimately the commercialization of the ownership and operation of space stations is the proper approach, but also believe that establishing the initial operating capability of a space station is beyond the capacity of the private sector because of the high initial investment in both R&D and construction and the high degree of risk involved. It is possible however that individual components of this initial capability can be provided by the private sector with proper coordination by NASA.

Q8. a. Do you feel that an agency should still monitor this activity or be like the FAA is to the airline industry?

A8a. Even if the ultimate embodiment of the space station and other orbital facilities is totally private ownership and operation, NASA coordination will still be essential because of the importance of these space assets to our national goals and interests. A major regulatory role for NASA might conflict with NASA's mission to promote space activity and conduct advanced R&D.

Mr. VOLKMER. Thank you very much, Mr. Wood.

At this time, I'll recognize Mr. Brown for any questions he may have.

Mr. BROWN. I am beginning to get a picture here which is rather exciting, and it leads me to think about the processes of historical development of the surface of the land and comparing them with what we're doing in space.

I can imagine Columbus going to Queen Elizabeth and saying, "If you'll just be a little more cooperative and friendly, we can open up a new frontier over in the Western Hemisphere where we think there are a lot of resources." And Queen Elizabeth arguing with him about how many regulations he was violating, and so on.

Actually, there's a—in your comments about the need for a user friendly bureaucracy, I'm more and more impressed by the parallel between our own development of our agricultural resources in this country where, of course, the original steps included giving title to the land in the form of either grants or a license to exploit the land and, then, 100 years ago, setting up the research and agricultural extension which was to provide a user friendly approach to the knowledge necessary to improve the resource.

And we've approached that with NASA over the years. We've made an effort to develop technology utilization programs and other kinds of outreach programs. But we've never been able to get across the idea that this was a key element in the exploitation of the commercial possibilities of space.

It appears that now we're seeing increasing pressures to develop that kind of a mechanism which would allow the Government and the individual entrepreneur or corporation to fruitfully interact and cooperate in a sitation that requires both in order to succeed. I'm pleased that the contribution which you've made emphasizes that point.

Let me ask you a small technical question, which I probably should have asked to the previous witnesses. We have a gravity—a relatively gravity-free environment in low-Earth orbit, not because the gravity isn't there, but because we neutralize it through the rotational force of the satellite. And technically or theoretically, we create an environment with any degree of gravity we wanted in that, if we wanted to spend the energy necessary to create the rotation.

Has that technical aspect ever entered into your discussions, the possibility of actually creating an Earth gravity, a one-G environment, if we wanted to, and how much it would cost in term of energy output?

Mr. WOOD. This was part of the early concepts that we heard about 20 years ago, a big structure that would rotate in space and create, if you will, artificial gravity. Perhaps maybe it would make it easier for people to work and live.

But, to my knowledge, it hasn't been a factor in the processes that have come up in our contact with industry. And I would like to defer to Dr. Weinberg, who has had a good deal of the very specific contact in these matters.

Mr. BROWN. Actually, you could have components of the system, the station, that some would have zero G and some could have any G.

Mr. WOOD. I think the mechanical problem is probably fairly easy to deal with in terms of the engineering.

It would add something significant to the cost, because it's a degree of complexity that's not contemplated right now in the initial capability. But there's no challenge there that couldn't readily be met by the space engineers we have today.

Whether there's a need for it right now, I don't know.

Dr. WEINBERG. Congressman Brown, the major excitement that industry sees is in the total absence over the microgravity environment. They would recognize that they, using centrifuges et cetera, created all degrees of gravity on Earth, and almost would reject any thoughts you had in that direction because they would automatically assume that that would be done less expensively on Earth.

There's a lot been written. What's happening in the method that Peter described, where we've been presenting concepts for people to grasp, is that people are grasping that in a microgravity environment, they are capable of solving Earth problems. And, as Peter said over and over again, until we get people who have lived in space for some time, they won't think forward into your kinds of issues.

Right now, everybody's thinking of solving earth problems in a space station. Sometime when somebody has lived in space for 30, 60, 90, or 120 days, and understands gravity and the absence of gravity, then I think the psychology of what happens when I get halfway in between or some alternatives will begin to come.

So what we're getting in industry today is people getting excited about solving Earth problems in the relative total absence of gravity, and not a lot of thinking of the variations in between.

Mr. WOOD. We're absolutely convinced that we've only begun to think of things that can be done. It's a little like the early days of the powered aircraft, where it was viewed as a toy, and the Signal Corps had to be persuaded very hard that they had some value. And look what we use it for today.

I think manufacturing and other manned events in space will far outstrip our ability to conceive of them today. We like to think of taking the first olive out of the bottle. The first company that makes a buck out of processing in space will be followed by a hoard of others who are then reminded of ways that they can make money, and the ideas will flow. And certainly they will flow with the experience we're talking about that we just haven't begun to get.

Mr. BROWN. Well, my thought on the zero-G environment is not to negate it completely in a space station, but your stay-time for a human being could be extended considerably if you had an environment which was not zero G for habitation. And the people up there don't work 24 hours a day.

Mr. WOOD. That's right.

Mr. BROWN. You could have your zero-G environment, in which they would do experiments maybe 4 hours a day, or do processing 4 hours a day, or it could be automated at a zero-G environment, but you could have permanent habitation only if you constructed an environment which was to some degree of gravity. We don't understand that problem fully yet.

It raises some interesting questions.

Mr. WOOD. It is a very useful thought, and I think it's part of the science that needs to be looked into. We need to get some hours in space with partial G.

Mr. BROWN. Now, I'm really more interested in the institutional problems that you have described which we've grappled with for many years.

In a sense, you and your contractor relationship constitute an effort by NASA to create that user friendly environment with the bureaucracy. That's your job, to encourage and nudge along the private enterprise to participate in this.

I'm wondering if that capability couldn't be better institutionalized, as it is in the Department of Agriculture, with some sort of a formal extension service which has real respectability, not what we have in NASA at the present time. And maybe we need to contemplate a Department of Space with the mission of exploiting space opportunities of all kinds, scientific as well as commercial, with its R&D Department and its Operating Department, its Transporation Department, and its Extension Department in order to provide the interface necessary to deal with it.

Has—I've never heard of NASA thinking in these terms, but have you encountered any thinking along these lines?

Mr. WOOD. Under our current contract, there is something called task 3 which asks us to do this kind of thinking, to give some thought to the various forms that an intermediary might take, and it might be a Government entity. It might be a Government-funded entity. It might be something unconnected to the Government, something that an industry association might support.

So we have the opportunity under that task which we are just now beginning to explore a whole range of activities. And that's one of the things that we'll give some thought to. And we'll examine the pros and cons of each of these alternative approaches.

Mr. BROWN. All right. Thank you very much.

Mr. VOLKMER. Mr. Wood, you mentioned that one small firm had some difficulty for approximately what, 3 years?

Mr. WOOD. Three and a half years.

Mr. VOLKMER. Three and a half years to get a JEA, a joint endeavor agreement?

Mr. WOOD. Yes.

Mr. VOLKMER. Have you looked into the problem with the JEA's, at least to——

Mr. WOOD. We're going to explore that one further with this individual who is the president of a small firm, and try to do a little cast study on it as part of our effort to find ways to make space more accessible.

There's another effort going on right now where the JEA is not yet executed, and we're trying to find out what the obstacles have been there.

I don't think it's totally inappropriate that it takes some time, because it represents for both parties a rather significant step. And in the case of NASA, which is a steward of public funds, they need to be careful how these resources are used, because there are lots of parties that would like to have the use of free rides on shuttle. So it's proper that they enter into this quite thoughtfully.

Nevertheless, it seems to me some streamlining is possible.

Mr. VOLKMER. Now, the technical aspects that you mention up there. Do you see any problems with arriving at solutions to those technical concerns?

Mr. WOOD. Well, Mr. Chairman, I think some of them have budgetary aspects. Certainly NASA would like to do more science then they're doing now. They have a backlog of unanswered questions. I think it's just a question of being able to find the right priority in the total scheme of things in the NASA budget.

There may be some questions in science that we're not smart enough to find the answers to in the near term. But, for the most part, I think those things can be worked out. I don't see a major obstacle there.

Mr. VOLKMER. All right.

On the—in your exploration discussions with businesses, do you see any potential for—at least in the near term—a commercial space station?

Mr. WOOD. I think it's quite possible that some modules of the space station can be provided by commercial investment.

Mr. VOLKMER. Well, let me turn it around for just a minute——

Mr. WOOD. All right.

Mr. VOLKMER [continuing]. And go back to where I should have started.

In the event that we should turn down a space station, whether it's the administration or Congress, and say, no, we're not going to go forward with it, what do you envision the prospects of the commercial world going ahead doing the whole thing?

Mr. WOOD. Well, I think it's a little like the question of an SST. I think it might just be too much to bite off, and it might be too difficult to get the different parties together with the kind of money to put it all together.

So I don't think it's likely that that would take place in the near term. It would certainly be very likely to represent a substantial delay in our having such a capability that, as John Hodge told you, the Soviets essentially have today.

Mr. VOLKMER. Now——

Dr. WEINBERG. There is one, if I may just make—as I think that question—there's one confounding issue, Congressman Volkmer, that has to be considered.

If you were to make that hypothesis that the—that the Government sector does not go forward at all and that all would fall to the private sector, there's one confounding issue which is what would the the Government do, however, to continue to provide shuttle access.

It might be very confounded that, if the Government did not go ahead, but would maintain shuttle operations and provide that activity for commercial interests that wanted to proceed and could get free shuttle rides, then there might be some commercial activity to produce a private-sector station. So the confounding activity is the access to the space transportation system and what the Government would do to maintain that.

If that were to have to become self-supporting, plus a private-sector space station, then I have to agree that I think—it's my feeling that that's an absolute impossibility.

Mr. WOOD. I'd like to add to my answer that it was in the context of a manned space station.

Mr. VOLKMER. Yes; I'm not talking about free flyers and things.

Mr. WOOD. That's right.

Mr. VOLKMER. Because I can see where those are utilized.

Mr. WOOD. Free flyers are certainly possible in the near term, yes.

Mr. VOLKMER. That would be, definitely, especially in conjunction with the shuttle.

Mr. WOOD. That's right.

Mr. VOLKMER. To go on with—you started to answer the—your answer to my original question was that, as I understand it, that there is probability of commercial modules—or, in other words, if we do the reverse, if we go ahead with the space station concept.

Mr. WOOD. You're quite right.

One of our most interesting concepts that came out of our seed concept work and has been given strength by the interests of a number of parties is the idea of a commercial fee-for-service laboratory in space. And we've talked to a number of firms, both on the technical side and in the venture capital side, and I think this is something that may very well come to pass. And it would be a component mated to the space station, and it would provide a place where people who have a question of scientific process can have some work done for them for a fee, and it would be a very effective resource, and it would be a national resources, in the sense that a huge wind tunnel is a national resource and many different users take advantage of it.

Mr. VOLKMER. Now, in the government end, the problems there, of course, we possibly are going to have an administrative change in the Congress every other election, or every election—every 2 years, almost. Do you see any problems? Has that come up as you talked to industry?

Mr. WOOD. Well, I think this is a program where there are concerns. But I think once it's started, it's probably going to gain the kind of momentum that the Apollo program had. And I think we're going to see some bipartisan support for something that is this much in the national interest.

I hope that's the case, and I'm sure the chairman could provide a better answer than I could on that point.

Mr. VOLKMER. I just wondered what industry—if that was one of the concerns in the industry, other than the bureaucracy.

Mr. WOOD. Let me ask Myron about that.

Dr. WEINBERG. That is an absolutely voiced concern, one that is articulated by senior management about if one finds a firm that is prepared to go ahead with a 6-, 8-, 10-year developmental program, then senior management will always surface a question about will the next administration cancel the space station.

Actually, my real feeling about that is it's an articulated concern, but it's one that does not get very serious interest. Once a company thinks it sees a reason to go ahead, then it will go ahead. Although this fear may exist, this will not become a very negative factor.

Mr. WOOD. Two kinds of signals could certainly help. One would be the kind of support in the committee and in the Houses of the

Congress who vote for it; and certainly a second might be the pronouncements of the out-of-office likely candidates who might support this the way sometimes compaigning candidates do offer support to something that is a national program, even though it has started in another administration.

Those signals would be watched very closely, I'm sure.

Mr. VOLKMER. Now, did your firm provide NASA with the list of the firms that have the interest in space that you found?

Mr. WOOD. I might add a little detail here and point out that there were names of firms that came out of each of the eight SSNAAO studies, the architecture studies, including the list that Booz, Allen developed at that time. And that list, in all, numbered something between 150 and 200.

We have been focusing on names from all of those lists. Some we found did not really amount to substantial interest on followup, and others did. Currently, we have a list of 25 firms from that list. Another list of 25 is being pursued by Coopers & Lybrand under a parallel contract. In addition, we've added some new starters to it. We right now have a list of about 35 active names that we're trying to carry on dialogs with.

We have identified to NASA all of the firms that we are working with, except in the few cases where the firm has asked not to be identified for reasons of confidentiality. More typically, the firm is willing to be identified, but they would like to conceal the concept for now.

So, NASA has a complete list of all the firms that were named in the eight studies, and they know most of the other firms we're dealing with except for a handfull, perhaps three or——

Mr. VOLKMER. In your opinion, out of these approximately 25 plus 10, how many would you say—without naming names or anything—would be possible viable candidates for utilization of the space station concept, manned space station concept?

Mr. WOOD. I believe something like five to eight right now that look like fertile prospects that may lead to commitment. And commitment might take the form of a JEA, and certainly will take the form of investment of time and money into developing concepts.

Would you agree to that, Myron?

Dr. WEINBERG. No; I believe that I would agree with Peter that the way we're going now, we have roughly a half a dozen firms that will make some resource commitment to the development in the next 12 months.

Mr. WOOD. Those are leaders we're talking about.

Mr. VOLKMER. Do you have any additional questions? I believe that——

Mr. BROWN. Can I bring up one just one additional thing—I'm reluctant to do this, but you mentioned a lead into it—the worry about the military preemption of the place on the space station by some businesses. You mentioned the possibility of being kicked off by the military.

That's highly unlikely since the military feels that a space station, at this point at least, is not compatible with their mission in space. But the odds are somewhat greater probably that the business would be blown off by some military activity on the other side.

Did you find that to be a concern at any point, the instability of international relations as a factor in the exploitation of space?

Mr. WOOD. Well, where concern was expressed about military presence, probably it was most often before the recent publicly announced conclusion by OSD that they had no requirement. A lot of our work was done before that decision was made known. We were privately aware that there was only a limited interest expressed during those eight studies, in which OSD had a small investment in the cost of the studies.

But, I don't think this military business was ranked very high in the concerns that we heard. Probably much higher would appear the matter of protection of proprietary rights and intellectual property vis-a-vis other firms and, to a lesser extent, vis-a-vis countries participating in the program.

Mr. BROWN. So, they're not much more worried about being blown out of space than they are being blown out of wherever else they may be?

Mr. WOOD. I don't think so.

Dr. WEINBERG. That's an exact description. You may notice that we work as a team.

Almost all the major firms are multinational, and basically they have that as a concern of doing business every single day.

Mr. BROWN. Let me ask you then one followup point I suggested earlier. Do you think that there would be any advantages in a sense of mutual insurance by the two sides, the United States and U.S.S.R., from some effort at the cooperative exploitation of the space environment, in the sense that it would make both sides more reluctant to take action to destroy their mutual assets in space?

Mr. WOOD. I think the question is a very interesting one, and I'm pleased that it came from a Californian, which is a clue to where I came from.

We have not studied that particular issue at all. But my opinion at this moment is that, yes, it would provide considerable assurance. You have to examine the disadvantages that go along with it. There would be some costs that you would pay.

But I think it's interesting to find that there is a fair amount of communication in the scientific community from one side to the other. And we're talking about something where the uses we're talking about are based on the best thinking of science. And I think the scientific communities on both sides, if they are allowed to express the idea, would welcome that opportunity. I think the synergism probably would produce some interesting results.

As far as we know, the Soviets know a great deal about the endurance of man in space right now, and that would be an interesting thing for us to have a bit more use of.

Mr. BROWN. Their men in space are, I think, almost exclusively—if not exclusively—military men. What we have the opportunity to do here is to demonstrate the superiority of a public-private cooperative approach to exploitation in space, which might have some good propaganda advantages, too.

Mr. WOOD. They might find it threatening to their way of thinking, too.

Mr. BROWN. That's what we want to do, change their way of thinking.

Mr. WOOD. I think the idea should be explored further.

Mr. VOLKMER. Thank you.

Thank you very much, Mr. Wood and the other witnesses. I appreciate your being here today.

The subcommittee will stand adjourned.

[Whereupon, at 12:40 p.m., the subcommittee was adjourned.]

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